Endobronchial Valves in the Treatment of Persistent Air Leak, an Alternative to Surgery

Rosa Cordovilla, Aldo Mateo Torracchi, Nuria Novoa, Marcelo Jiménez, Jose Luis Aranda, Gonzalo Varela, Miguel Barrueco

Servicio de Neumología, Hospital Universitario de Salamanca, Salamanca, Spain
Servicio de Cirugía Torácica, Hospital Universitario de Salamanca, Salamanca, Spain

A R T I C L E   I N F O

Article history:
Received 5 March 2014
Accepted 26 April 2014
Available online 1 December 2014

Keywords:
Endobronchial valve
Alveolar-pleural fistula
Persistent air leak
Pneumothorax

A B S T R A C T

Introduction: Persistent air leak is frustrating for both patients and physicians, above all leaks with a high risk of surgery. Insertion of endobronchial valves could be an alternative to surgery. The aim of this study is to describe our experience in these valves and analyze their efficacy in a series of patients with persistent air leaks.

Materials and methods: The valves are inserted by means of flexible bronchoscopy under conscious sedation and local anesthesia. A preliminary bronchoscopy identifies the air leak by bronchial occlusion using a balloon catheter. A successful outcome is defined as complete disappearance of the leak following removal of the chest drain, without the need for further surgery.

Results: From November 2010 to December 2013, 8 patients with persistent air leaks were treated with endobronchial valves. The number of valves used ranged from 1 to 4 (median 2), with a median duration of air leak prior to placement of 15.5 days. There were no complications and the resolution of the leak was complete in 6 of 8 patients (75%). The median duration of drainage after insertion of the valves was 13 days and the median time to removal of 52.5 days.

Conclusions: Insertion of endobronchial valves is a safe and effective method for treating persistent air leaks, and a valid alternative to surgery.

© 2014 SEPAR. Published by Elsevier España, S.L.U. All rights reserved.

Válvulas endobronquiales para el tratamiento de la fuga aérea persistente, una alternativa al tratamiento quirúrgico

R E S U M E N

Introducción: La fuga aérea prolongada es motivo de frustración entre médicos y pacientes, sobre todo para aquellos con alto riesgo quirúrgico. El uso de válvulas endobronquiales podría ser una alternativa al tratamiento quirúrgico. El objetivo de este trabajo es mostrar nuestra experiencia con el uso de las mismas y analizar su eficacia en una serie de casos tratados por fuga aérea persistente.

Material y métodos: La colocación de las válvulas se realiza mediante broncoscopia flexible, bajo sedación consciente y anestesia local. La fuga aérea se identifica, en un primer paso, mediante la oclusion del bronquio con un catéter-balón durante una broncoscopia. El éxito del procedimiento se define como la desaparición completa de la misma, con la retirada del drenaje torácico sin necesidad de otros procedimientos posteriores.

Resultados: De noviembre de 2010 a diciembre de 2013 se han tratado 8 pacientes por fuga aérea persistente con válvulas endobronquiales. El número de válvulas utilizadas osciló entre 1 y 4 (media de 2), con una mediana de duración de la fuga aérea previa a su colocación de 15,5 días. No hubo
Introducción

El persistente fuga aérea (PAL) es causado por un mal funcionamiento del sistema de ventilación entre el espacio alveolar y el espacio pleural, persistiendo más de 5-7 días.

Se produce como complicación en hasta el 15% de los casos de toracotomía, en pacientes con enfermedad pulmonar e incluso en pacientes con insuficiencia respiratoria, que presentan una enfermedad pulmonar subyacente (tumor bronquial, neumotórax, aspiraciones transtorácicas) o una complicación de la misma, como la neumonía, la neumotórax, la neumotórax desde la aspiración transtorácica, o una neumotórax desde la aspiración transtorácica.\(^2\)

El PAL se desarrolla en pacientes con enfermedad pulmonar crónica y/o enfermedades múltiples, y está asociado con el mal funcionamiento de las válvulas de cierre, que se utilizan para mantener el aire dentro del tórax y evitar la expansión del aire distal a la válvula.\(^3\)\(^4\)\(^3\)\(^5\)

El PAL ha sido comúnmente manejado con cirugía, sin embargo, debido a las complicaciones mencionadas, algunos pacientes no pueden ser intervenidos quirúrgicamente. Para esta razón, se han desarrollado técnicas endoscópicas que incluyen la colocación de válvulas endobronquiales (EBV). Estas válvulas ofrecen un buen eficaz y se han utilizado en varios casos.\(^6\)\(^7\)\(^6\)

EBV se diseñaron para el tratamiento endoscópico de la pérdida de volumen del pulmón o la neumotórax, y fueron utilizados para el tratamiento de PAL. El dispositivo funciona de una manera similar a la válvula de Heimlich, permitiendo el flujo de aire hacia los pulmones y el aire en la dirección de proximal.\(^6\)\(^7\)\(^8\) En algunos casos, la pérdida de la válvula o expansión del segmento proximal se ha utilizado como medio de tratamiento para la consolidación de la fuga aérea y la reducción del dano pulmonar.\(^9\)

Se presentan resultados de un estudio en 8 pacientes con PAL persistente, tratados con válvulas endobronquiales, comparando los resultados con series publicadas en el pasado.

Materiales y Métodos

Población

Un estudio prospectivo fue llevado a cabo con 10 pacientes que fueron evaluados para la colocación de válvulas endobronquiales entre octubre de 2010 y noviembre de 2013 debido a PAL persistente. Los pacientes que fueron evaluados fueron excluidos de la intervención debido a complicaciones quirúrgicas, alteraciones pulmonares significativas o pacientes cuyos antecedentes quirúrgicos no fueron adecuados para el tratamiento de PAL.

Procedimiento

La colocación de válvulas se realizó mediante broncoscopia flexible, bajo sedación y anestesia local. La primera etapa de la colocación de válvulas se realiza mediante la identificación endoscópica del origen de la fuga aérea, lo que se identifica mediante occlusión de la válvula durante la broncoscopia flexible (Fig. 1A y B).

Conclusiones: El uso de válvulas endobronquiales es un método efectivo y seguro para el tratamiento endobronquial de la fuga aérea prolongada y una alternativa válida a la cirugía.

© 2014 SEPAR. Publicado por Elsevier España, S.L.U. Todos los derechos reservados.
Figure 1. (A) Occlusion balloon in the posterior segment bronchus of the left lower lobe. (B) Occlusion balloon in the anterior segment bronchus of the left lower lobe.

Figure 2. Endobronchial valves located in the segmentary bronchi. (A) IBV valve in right B1 and B2. (B) Z-EBV valve in right B1.

Figure 3. Images obtained after IBV valve placement (patient no. 8). (A) Chest X-ray with IBV valves in right upper lobe. (B) Detail of chest X-ray with IBV valves in right upper lobe. (C) Chest X-ray in patient with bullous emphysema and IBV valve in right B2 (indicated by the arrow). (D) Chest X-ray in patient with bullous emphysema and IBV valve in right B1 (indicated by the arrow).
Nine procedures were performed in 8 patients with PAL. The series consisted of 7 men and 1 woman, with a mean age of 68.5 years. All patients have significant comorbidities, including severe pulmonary emphysema in 7 patients, respiratory failure in 5, thrombopenia <20,000 platelets per microliter in 1 and ischemic heart disease in 1 patient. In 6 patients, PAL occurred after development of a spontaneous pneumothorax secondary to underlying lung disease (Fig. 4A and B), after treatment-related pneumothorax in 1 and after anatomical resection of lung cancer in 1.

Air leak was continuous in 5 cases and intermittent in the other 3. On average, 2 valves were placed per patient (IBV in 7 and Z-EBV in 1), with a mean pleural drainage time before insertion of 15.5 days. One patient with secondary spontaneous pneumothorax (case no. 8) did not initially respond to valve placement in the right lower lobe. The patient underwent surgery, but this was also ineffective, so a new EBV was placed in the right upper lobe and the clinical picture was finally resolved.

No complications were recorded during the procedure, mean time of pleural drainage after valve placement was 13 days and leakage was stopped in 6 patients, giving a success rate of 75% in our patients. There were no adverse events associated with the implant during the 3 months of follow-up.

The valves were left in place for a median time of 52.5 days, although in 1 case it was not removed until 2 years later, as the patient failed to attend the follow-up visit. Patient characteristics are described in Table 1.

Discussion

In this paper we report the largest series of patients with PAL treated with implantation of endobronchial valves published to date in Spain. This treatment was effective in secondary pneumothorax and pneumothorax after lung resection. Complete cessation of leakage in our patients was achieved in 75% of the cases, with no need for other procedures after withdrawal of the chest tube.

Relatively few studies in the literature have addressed this issue. In general, retrospective case series with a small heterogeneous population in terms of patient characteristics and air leak etiology have been described. The first case of a PAL successfully treated with endobronchial valves in the world literature was published in 2006 by Feller-Kopman et al.12 in Spain, the only publication on this subject was that of Rosell et al.13 which appeared in 2010. The largest series are those published by Travaline et al.14 with 40 patients, reporting a success rate of 48% and by Firlinger et al.15 in 2013, reporting on 16 patients with a success rate of 76.9%. Other publications report case series of between 1 and 7 patients.8,9,12,13,16–23

These articles were reviewed, and without taking into account the heterogeneity of the sample, the use of valves has been reported in 90 patients. Complete resolution of air leak in 63% of these patients (57 patients) and partial resolution in 28% (26 cases) was achieved. Mean number of valves used in all the reports was 3.

In general terms, all these reports present EBV as a valid alternative for the treatment of PAL, coinciding with the findings of our study. However, ideal candidates for this treatment cannot be clearly identified from these results. In our series, 3 patients had to undergo surgery, despite their severe comorbidities, as the air leak was not completely resolved after EBV placement. The first of these underwent an intervention 14 days after valve placement. In this patient, the occlusion test may have been unsuccessful as the air leak, being intermittent, was difficult to identify. In the second patient, the air leak was so severe that despite EBV treatment, the decision was taken to operate on day 5. In the third case (case no. 8), surgery after valve placement was unsuccessful, so a second non-invasive procedure was performed for placement of new EBV that were effective in stopping the air leak.

When PAL is intermittent, it can be difficult to locate the air leak using the occlusion test, particularly if it is not completely stopped and only some reduction is observed. Firlinger et al.15 excluded patients with intermittent leak from their study, and this would explain the greater success rate in their series compared to the figures published in the literature. Moreover, they used a digital measurement system that may have helped in the selection of patients for this type of treatment. In our series, a similar success rate was obtained, despite the inclusion of 3 cases with intermittent air leak.

Since the series was small, it is difficult to determine reasons for response or non-response to EBV, suggesting that prospective

Table 1
Description of Patients and Procedures.

<table>
<thead>
<tr>
<th>Characteristics of patients</th>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Days of previous drainage</th>
<th>Site of air leak</th>
<th>Type of air leak: intermittent/C: continuous</th>
<th>No. of valves</th>
<th>Size of valve (mm)</th>
<th>Type of valve</th>
<th>Days of drainage after EBV</th>
<th>Treatment success</th>
<th>Surgery after EBV</th>
<th>Valve extraction (days)</th>
<th>Relapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>1</td>
<td>55</td>
<td>Male</td>
<td>Silicosis Post TB</td>
<td>15</td>
<td>RLL</td>
<td>C</td>
<td>4</td>
<td>6 α 7</td>
<td>IBV</td>
<td>14</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Age</td>
<td>2</td>
<td>85</td>
<td>Male</td>
<td>COPD Silicosis</td>
<td>16</td>
<td>Lingula</td>
<td>C</td>
<td>1</td>
<td>6</td>
<td>IBV</td>
<td>4</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sex</td>
<td>3</td>
<td>66</td>
<td>Male</td>
<td>COPD Bulla</td>
<td>14</td>
<td>RUL</td>
<td>C</td>
<td>2</td>
<td>6</td>
<td>IBV</td>
<td>6</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>4</td>
<td>28</td>
<td>Female</td>
<td>COPD Post TB</td>
<td>90</td>
<td>LUL</td>
<td>C</td>
<td>3</td>
<td>6</td>
<td>IBV</td>
<td>1</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Days of previous drainage</td>
<td>5</td>
<td>69</td>
<td>Male</td>
<td>COPD Post-resection</td>
<td>22</td>
<td>RUL</td>
<td>C</td>
<td>2</td>
<td>4</td>
<td>Z-EBV</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Site of air leak</td>
<td>6</td>
<td>74</td>
<td>Male</td>
<td>COPD COPD</td>
<td>22</td>
<td>LLL</td>
<td>C</td>
<td>1</td>
<td>7</td>
<td>IBV</td>
<td>15</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Type of air leak: intermittent/C: continuous</td>
<td>7</td>
<td>72</td>
<td>Male</td>
<td>COPD COPD COPD</td>
<td>8</td>
<td>RLL</td>
<td>C</td>
<td>1</td>
<td>12</td>
<td>IBV</td>
<td>15</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No. of valves</td>
<td>8</td>
<td>68</td>
<td>Male</td>
<td>COPD COPD COPD</td>
<td>12</td>
<td>RUL</td>
<td>C</td>
<td>1</td>
<td>6</td>
<td>IBV</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>


* Two procedures were performed, the second after surgery.
studies and analyses of predictors for success in this type of treatment would be of interest: type and volume of PAL, age, cause of leak, previous lung function, body mass index, etc.

Extrapolating from the work of Wan et al. in the context of volume reduction treatment, possible complications of the procedure include pneumonia, empyema, hemoptysis, and respiratory failure. Mortality is low and associated more with the underlying disease than the procedure. Jenkins et al. also described valve migration as a possible complication and in the series published by Travaline et al., patients with incorrect valve positioning, expectoration of a valve, moderate desaturating, pneumonia, and colonizing of the valve with methicillin-resistant *Staphylococcus aureus* were reported. Another significant complication mentioned in the literature is dyspnea and respiratory failure due to bronchial occlusion in patients with emphysema and with prior lung resection for lung cancer. In this respect, Dooms et al. described a case in which, after right lower lobectomy, occlusion of the bronchi of the right upper lobe produced no atelectasis of that lobe, probably due to collateral ventilation. However, collateral ventilation does not prevent leakage closure after valve insertion, since the valve itself reduces the passage of air, allowing the lung to heal. No atelectasis was found in our series, so none of the patients experienced increased dyspnea or oxygen desaturations after valve placement. Moreover, development of atelectasis over time was not expected as full lobe occlusion was not performed in any of our cases. To sum up, in our series the procedure was safe and well-tolerated and free of complications. No complications developed during the 3 months of follow-up, although the youngest patient had a recurrence, in the form of a small apical chamber that did not require drainage and was resolved with respiratory physiotherapy. As in other studies, the limitations of a lack of control group, the small sample size and the range of causes of air leak must be mentioned.

**Conclusion**

Treatment of persistent air leak with endobronchial valves is minimally invasive, effective, and safe. It is a good alternative for patients with high surgical risk. The results of our series are similar to those published by other groups of investigators, and the study presents the same weaknesses: it is retrospective, the sample size is small, and the causes of PAL are heterogeneous. Well-designed prospective studies are needed to confirm the indications for EBVs and factors predictive of success.

**Authors’ Contribution**

Dr. Cordovilla was responsible for conducting procedures, study concept and design, data collection, analysis and interpretation, drafting the manuscript and review of its intellectual content and review of the final version submitted for evaluation.

Dr. Torracchi participated in conducting the procedures, study concept and design, data collection, analysis and interpretation, drafting of the manuscript and review of its intellectual content, and review of the final version submitted for evaluation.

Dr. Varela participated in conducting the procedures and in the review of its intellectual content and review of the final version submitted for evaluation.

Dr. Jiménez participated in conducting the procedures and in the review of its intellectual content and review of the final version submitted for evaluation.

Dr. Aranda participated in conducting the procedures and in the review of its intellectual content and review of the final version submitted for evaluation.

Dr. Novoa participated in conducting the procedures and in the review of its intellectual content and review of the final version submitted for evaluation.

Dr. Barrueco contributed to the review of the intellectual content of the manuscript and review of the final version submitted for evaluation.

**Conflicts of Interests**

The authors do not have any conflict of interests.

**Acknowledgements**

Our thanks to Manuel Lanchas Hernando, Mª José Rodríguez Celador and Emilia Pedraz Rivas, for their contribution and daily assistance during the endoscopic procedures.

**References**


