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Bronchial sleeve resections: lung function resurrecting procedure

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Abstract

Objective: Mainstem bronchus obstruction results in lung function exclusion. The aim of this study was to revisit lung function restoration obtained by different types of bronchial sleeve resections in selected patients with endobronchial tumors. **Methods:** Eleven patients (9 women and 2 men, mean age 47 years) presented with endobronchial tumors and ipsilateral lung function exclusion. Mainstem bronchial sleeve resection was performed in 7 patients, right bilobar and mainstem bronchial sleeve resection in 2, and left upper sleeve lobectomy in 2. Tumors consisted in 8 bronchial carcinoids, 2 adenoid cystic carcinomas, and one inflammatory myofibroblastic tumor. Fiberoptic bronchoscopy and quantitative ventilation—perfusion lung scan were performed in all patients at work-up to assess lung function exclusion and during the first year following bronchoplastic procedure to study recovery. Long-term follow-up consisted of physical examination, thoracic computed tomographic scan and bronchoscopy every year. **Results:** There was no postoperative death. The long-term follow-up was complete and ranged from 12 to 192 months (median: 102.7 months). The lung function was completely restored in all patients. The ventilation function was immediate, but the perfusion was restored in a mean interval of 8.2 months (ranging from 3 to 12 months). All patients are currently alive, and no local tumor recurrence was observed. **Conclusions:** Some obstructing tumors may be removed by various types of bronchial sleeve resections that permit lung function restoration and long-term local control of the disease. However, at least one year is required for lung perfusion to completely recover, despite immediate ventilation restoration.

Keywords: Lung cancer; Bronchial sleeve resection; Vasoconstriction; Lung function

1. Introduction

Airway obstruction is known to cause hypoxic pulmonary artery vasoconstriction. This disorder, induced by a trapping effect and related to reflex phenomena and anatomical modifications, results in lung function exclusion [1—4]. The aim of this study was to further explore ventilation and perfusion lung function restoration following 'different types of' bronchial sleeve resections for tumors obstructing the mainstem bronchus.

2. Materials and methods

From 1981 to 2006, 11 patients with impaired lung function due to tumoral lung obstruction and subsequent pulmonary artery vasoconstriction underwent bronchoplastic procedures. There were 9 women and 2 men with a mean age of 46.9 years (range, 24—72 years). Bronchoscopy with biopsy was performed in all patients. Preoperative work-up included thoracoabdominal and cerebral computed tomographic (CT) scan. Lung function was evaluated by pulmonary function tests, and pulmonary artery vasoconstriction by perfusion lung scan (^{99m}Tc). The resection was performed on the right side in 5 patients and on the left in 6 patients.

The preoperative median force expiratory volume in one second (FEV_1) was 64.1% of predicted normal and ranged from 35% to 82% of predicted normal. The mean value of the perfusion fraction of the affected lung was 3% and ranged from 0% to 20%.

2.1. Operative techniques

Standard double-lumen tube was used for one-lung anesthesia, and the operation was performed through a posterolateral thoracotomy in all patients.

The distal trachea and ipsilateral mainstem bronchus were mobilized. The distal and proximal mainstem bronchi were transected and once the specimen removed, frozen

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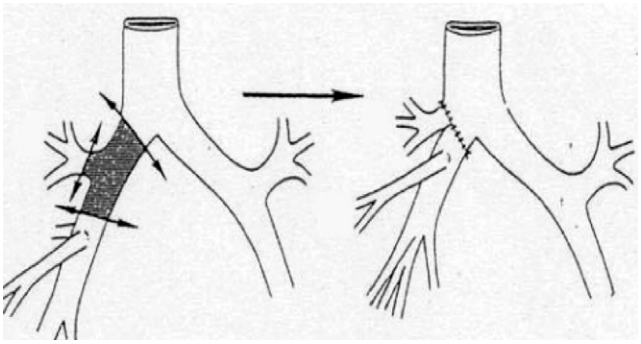

Fig. 1. Bibronchial and mainstem bronchial sleeve resection.

section analysis of the margins was performed to determine the adequacy of resection.

Different types of surgical procedures were used to remove the endobronchial tumors, which presented as following:

- Bronchial tumor resection and mainstem bronchial anastomoses in 7 patients.
- Left upper sleeve lobectomy because of margin involvement demonstrated by frozen section in 2 patients.
- Bibronchial and mainstem bronchial sleeve resection, consisting of anastomosing the proximal mainstem bronchus with the laterally sutured upper lobar and intermedius bronchi in 2 patients (Fig. 1).

Lung function was evaluated by quantitative ventilation–perfusion lung scans during the 12 months following surgery and have been performed at scheduled intervals regarding two programs. The first lung scan was routinely performed at 3 months. Pulmonary function testing was also performed one year after resection. Endobronchial result was examined by fiberoptic bronchoscopy before hospital discharge and then every year.

3. Results

Patient's characteristics are detailed in Table 1. Tumors totally obstructed mainstem bronchus in 9 cases and subtotally in 2 cases. Mean duration of preoperative atelectasis was 23 months (6–60 months in 8 patients). Resection was complete in all patients. Tumors consisted in bronchial carcinoids ($n = 8$), adenoid cystic carcinomas ($n = 2$) and in one inflammatory myofibroblastic tumor. The

Table 1
Characteristics of the patient population and the tumors

Characteristics	Gender	Age	Side	Histology	Duration of preoperative atelectasis (months)	Tumor diameter (mm)
Patient 1	Female	56	Right	Ca T	6	12
Patient 2	Female	45	Right	Ca T	6	15
Patient 3	Female	49	Left	Ca T	36	8
Patient 4	Female	51	Left	Ca T	36	7
Patient 5	Female	44	Left	Ca T	NA	15
Patient 6	Female	24	Right	Ca T	60	16
Patient 7	Female	29	Right	Ca T	NA	14
Patient 8	Male	45	Left	Ca T	NA	14
Patient 9	Male	57	Right	ADC	8	15
Patient 10	Female	72	Left	ADC	24	15
Patient 11	Female	44	Left	IMT	8	12

Ca T: carcinoid tumor; ADC: adenoid cystic carcinoma; IMT: inflammatory myofibroblastic tumor; NA: not available.

Table 2
Evolution of the lung function tests and the pulmonary perfusion during follow-up

Characteristics	Preoperative FEV_1 (%)[c]	Preoperative lung perfusion[a] (%)	Postoperative lung perfusion[a]	Delay for pulmonary perfusion recovery (months)	Surgical procedure	Postoperative FEV_1[b] (%)[c]	Follow-up (months)
Patient 1	70	20/80	55/45	3	LBSR	85	96
Patient 2	74	15/85	50/50	3	MBSR	91	137
Patient 3	61	0/100	35/65	6	MBSR	90	185
Patient 4	59	0/100	25/75	12	MBSR	100	171
Patient 5	70	0/100	20/80	12	MBSR	90	132
Patient 6	53	0/100	20/80	10	MBSR	103	24
Patient 7	35	0/100	25/75	10	MBSR	90	12
Patient 8	65	0/100	–	–	SL	80	12
Patient 9	69	0/100	20/80	12	LBSR	90	192
Patient 10	68	0/100	25/75	12	MBSR	106	145
Patient 11	82	0/100	–	–	SL	85	24

FEV_1: forced expiratory volume in one second; MBSR: mainstem bronchial sleeve resection; LBSR: lobar bronchial sleeve resection (right side); SL: sleeve lobectomy.
[a] Collapsed lung compared with controlateral lung.
[b] Measured one year after surgery.
[c] % to theoric FEV_1.

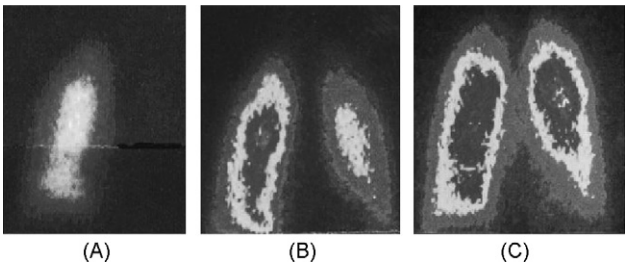

Fig. 2. Evolution of the lung perfusion recovery on scans in a patient with a carcinoid tumor of the left mainstem bronchus (A: preoperative scan, B: 3 months after surgery, C: 12 months after surgery).

median diameter of the resected tumors was 13.2 mm on the right side (12—15) and 11.8 mm on the left side (7—15).

Follow-up was complete for all patients and ranged from 12 to 192 months (median duration, 102.7 months). Evolutions of the lung function tests and of the pulmonary perfusion during follow-up are shown in Table 2. The postoperative median FEV_1 was 91.8% of predicted normal ranging from 80% to 106%. The preservation of the non-functional lung permitted a large increase of the FEV_1 (mean = 27.7%) at one year following surgery. The mean period of time for the restoration of normal lung perfusion after mainstem bronchial resection (n = 9) was 8.8 months, ranging from 3 to 12 months (Fig. 2). In effect, the 2 patients with incomplete arterial vasoconstriction (and who underwent bilobar with mainstem bronchial sleeve resection, and right mainstem bronchial sleeve resection), recovered a normal lung perfusion at their 3 months first control. The period to obtain the restoration of lung perfusion was also one year for one patient undergoing left upper sleeve lobectomy, and the remnant lobe restored function reached 27%. No patient died during the follow-up, no stenosis even after complex repairs was found (Fig. 3) and no local recurrence was detected.

Fig. 3. CT bronchogram ten years after bibronchial and mainstem bronchial sleeve resection.

4. Discussion

Hypoventilation caused by tumoral endobronchial obstruction induces reflex pulmonary vasoconstriction, a result from alveolar hypoxia [2]. Perfusion is redistributed to the other lung to maintain pulmonary blood flow to the well-ventilated alveoli. This phenomenon, described by Von Euler and Liljestrand [1] is an autoregulatory mechanism adjusting regional ventilation—perfusion ratios. This hypoxic arterial response depends on the availability of calcium to smooth muscle cells of the pulmonary arterial wall cells [5—8]. When this response is impaired, intrapulmonary functional shunting induces severe hypoxemia.

Ward and colleagues [3] reported that the delay of the return to normal perfusion was dependent on the vasoconstriction level before surgery. This was confirmed by our study: both patients with incomplete arterial vasoconstriction recovered normal function by 3 months, whereas patients with completely abolished pulmonary perfusion recovered in a mean period of time of 8 months. These results were in agreement with previous case reports also stating that a prolonged time was required for perfusion to return to normal [9—11].

Low-grade malignancies require only minimal clear margins for cure and are ideally suited to bronchoplastic resections without the need to sacrifice any lung parenchyma [12].

Carcinoid tumors were predominant in our study as it was previously reported in the largest series of parenchymal-sparing mainstem bronchial resection [13,14]. Bronchoplastic procedures not only for low-grade malignant tumors but also for non-small cell lung cancer [13,14] of the airway are indicated whenever anatomically suited lesions exist, and mainstem bronchial resection is not the only procedure. In 4 of our patients, the main bronchial tree was obstructed, and sparing pulmonary parenchyma was possible only when combining mainstem bronchial resection with resection of upper lobar and intermedius bronchi on the right in 2 patients, and mainstem bronchial resection with upper lobectomy (sleeve lobectomy) on the left in 2 patients.

In the 2 latter cases, the tumor obstructed the main bronchus and surgery resulted in reperfusion of the remaining lobe and lung function improvement. Sleeve lobectomy is mainly reported as an alternative to pneumonectomy in case of lung cancer. Initially performed in selected patients with poor lung function and not amenable to a pneumonectomy, sleeve lobectomy is now demonstrated to achieve similar long-term results with decreased morbidity and mortality. Deslauriers and colleagues [15] determined that the reimplanted lobe contributes to pulmonary function with minimal change in ventilation and perfusion. Gaissert and colleagues [16] demonstrated that the operated lung carried out expected proportional function. Khargi and colleagues [17] demonstrated that there was complete recovery of function of the reimplanted lobe at 4 months. Some of the lung cancers suitable for sleeve lobectomy may also be partly obstructing the main bronchus and the bronchus of the other lobe. We suggest that sleeve lobectomy not only salvage the other lobe function but may also ameliorate its perfusion by relieving some degree of vascular constriction in such cases. This hypothesis should provide another probably overlooked

beneficial effect of sleeve lobectomy 'deserving more attention'.

In conclusion, this study emphasizes that a prolonged time may be required for perfusion to return to normal after complete restoration of the ventilation. The delay is shorter in cases of incomplete vasoconstriction. Main bronchial resection is an ideal technique for selected malignant lesions, not only allowing pulmonary parenchyma preservation but also lung function literally to resurrect.

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