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Bronchial bacterial colonization in patients with resectable lung carcinoma

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Bronchial bacterial colonization in patients with resectable lung carcinoma. M. Ioanas, J. Angrill, X. Baldo, F. Arancibia, J. Gonzalez, T. Bauer, E. Canalis, A. Torres. ©ERS Journals Ltd 2002.

ABSTRACT: The pattern and clinical implications of bronchial bacterial colonization have been widely investigated in patients with chronic lung disease, particularly chronic obstructive pulmonary disease. The main aim of this study was to determine the frequency and risk factors for bronchial colonization in lung cancer patients who have undergone surgical resection.

Forty-one patients with resectable lung cancer (22 (54%) active smokers, 52±23 pack-yrs) with a mean forced expiratory volume in one second of 80±16% predicted, were studied with bilateral protected specimen brush and lung tissue biopsy during the surgical procedure. Quantitative bacterial culture, susceptibility tests and histological examination of samples were performed.

Bronchial colonization with ⩾1 potential pathogenic micro-organism was found in 17 of 41 (41%) patients. The most frequent strains isolated were: *Haemophilus influenzae* (35%), *Streptococcus pneumoniae* (13%) and *Pseudomonas* spp. (9%). The risk factors for bronchial colonization were central location of the tumour (odds ratio (OR)=9.2, confidence interval (CI) 95%=2.1–39.6, p=0.003) and increased body mass index (OR=1.6, CI 95%=1.2–2.2, p=0.005). The frequency of postoperative infectious pulmonary complications was low (five cases (12%)) and no relationship was observed with bronchial colonization.

Patients with resectable lung carcinoma had a high rate of bronchial colonization (41%), mainly with potential pathogenic microorganisms. The independent risk factors for colonization in these patients were central location of the tumour and a high body mass index.

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Improved methods for early detection of lung cancer have allowed an increasing number of patients to benefit from surgical treatment. Nevertheless, a concomitant increased risk of pulmonary complications and death has been reported in these patients [1]. SWARTZ *et al.* [2] found a perioperative mortality rate of 10.9% after pneumonectomy. Nosocomial pneumonia is one of the main causes of postoperative mortality [3], with several factors related to this condition, such as surgical stress, nutritional status, cancer-related immunosuppression and pre-existing diseases (chronic obstructive pulmonary disease (COPD), diabetes mellitus, *etc.*) [4, 5].

Bronchial bacterial colonization may be frequent in patients with lung cancer as most of these patients have underlying COPD, which is known to be associated with a high colonization rate. For example, MONSO *et al.* [6] found a colonization rate of 25% in patients with stable COPD. Very few studies have investigated the pattern of distal airway colonization in patients with bronchial carcinoma. CABELLO *et al.* [7] reported that 42% of patients with pulmonary carcinoma had bronchial colonization with commensal or potential pathogenic micro-organisms (PPMs). Although there is evidence of the role of bronchial colonization and the subsequent development of nosocomial pneumonia in intensive-care unit patients [8], no data are available on this relationship in patients after lung cancer resection.

Since this field has been investigated less than colonization in patients with COPD or bronchiectasis, the aims of this study were to establish the profile of bronchial colonization in patients with resectable lung cancer and to determine the risk factors associated with this condition, in order to increase understanding of the aetiology and prevention of postoperative infective pulmonary complications in patients undergoing lung resection.

Material and methods

Patients

This prospective study included 41 patients with lung cancer attending the Dept of Thoracic Surgery

from January 1998–June 1999. The selection criteria were: 1) diagnosis of lung cancer (histological criteria); 2) suitability for resection and operability using tumour, node, metastasis (TNM) classification and cardiopulmonary assessment; 3) no antibiotic treatment during the 14 days prior to surgery. Patients who did not fulfill these criteria and those with a history of recent myocardial infarction, cardiac failure or arrhythmia were not included in the study. The Ethical Committee of the Hospital Clinic approved the study protocol. Informed consent was obtained from all the patients.

Study design

The patients' characteristics (age, sex, smoking habits (pack-yrs), alcohol ($g \cdot day^{-1}$), comorbidity, Karnofsky index, and body mass index (BMI)) were recorded before surgery (table 1). Lung function tests (forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), diffusion capacity for carbon monoxide ($D_{L,CO}$) and gas exchange) and computed tomography (CT) scan for TNM staging were performed in all of the patients. The cell type of the tumour was established from pre-operative histological examination of a lung tissue sample obtained by bronchoscopic biopsy or CT-guided transthoracic needle biopsy.

Pre-operative cardiac evaluation was based on clinical history and electrocardiography in each patient. Perioperative respiratory sampling by bronchoscopy with protected specimen brush (PSB) and sampling of the resected lung tissue were performed in all patients. The samples were cultured according to standard procedures and tissue samples were examined histologically. Patients were followed until discharge from hospital to record postoperative complications.

Table 1. – Baseline characteristics in patients undergoing surgical resection for lung cancer

Characteristics	
Patients n	41
Male	37 (90)
Age yrs	64±21
Smokers/exsmokers	22 (54)/19 (46)
Pack-yrs*	52±23
<40	9 (23)
>40	30 (77)
Alcoholics/exalcoholics	13 (32)/3 (7)
Alcohol $g \cdot day^{-1}$	71±40
COPD	33 (80)
Diabetes mellitus	9 (22)
Karnofsky index	85±15
Body mass index>25	22 (54)
Pulmonary function	
FVC % pred	88±15
FEV_1 % pred	80±16
>80% pred	23 (57)
70–80% pred	7 (17)
<70% pred	10 (26)
FEV_1/FVC %	67±10
$D_{L,CO}$ % pred	76±16
Tumour characteristics	
Central/peripheral tumour	15 (37)/26 (63)
Squamous carcinoma	20 (49)
Adenocarcinoma	8 (20)
Surgical intervention	
Lobectomy	28 (68)
Pneumonectomy	8 (20)
Atypical resection	1 (2)
Exploratory thoracotomy	4 (10)
Previous hospitalization days	3±1

Data are presented as mean±SD or n (%) unless otherwise stated. COPD: chronic obstructive pulmonary disease; FVC: forced vital capacity; FEV_1: forced expiratory volume in one second; $D_{L,CO}$: diffusion capacity for carbon monoxide; % pred: % predicted.

Procedures

Bronchoscopy (fibreoptic bronchoscope BF30; Olympus, New Hyde Park, NY, USA) was performed perioperatively, after anaesthesia and endotracheal intubation and before proceeding to the surgical intervention. Tumour location was considered central if it was accessible by bronchoscopy, and peripheral when there was no bronchoscopic evidence of an endobronchial tumour [9]. A PSB technique (Microbiology brush, Mill-Rose Laboratory Inc. 7310, Mentor, OH, USA) was used for sampling bronchial secretions from the site of the tumour (pre-obstructive area) and from the contralateral lung. Each sample was collected in 1 mL sterile saline solution and then diluted at 10^{-1}, 10^{-2}, 10^{-3} and inoculated on standard media: blood agar, chocolate, Centre for Disease Control (CDC)-agar, McConkey, Sabouraud and Lowenstein, in aerobic and anaerobic conditions. Cultures were evaluated after 24 h, 48 h, 7 days (for CDC, blood agar) and 4–8 weeks (for Sabouraud and Lowenstein).

After surgical resection, a sample of the tumour and a sample of the post-tumoural area (dimension 2×2×2 cm) were collected under sterile conditions. The latter was divided into two equal fragments, one for microbiological investigation and the other for histological examination. Quantitative cultures were performed with all secretions and lung tissue samples. A cut-off of $\geqslant 10^2$ colony forming units (cfu)$\cdot mL^{-1}$ was used to define colonization [7]. Susceptibility tests using the E-test method were carried out for positive growth. Bacteria were classified as PPMs and non-PPMs as described elsewhere [7]. The PPM group included the micro-organisms usually responsible for respiratory infections (*e.g. Haemophilus influenzae*, *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Moraxella catarrhalis*, *Pseudomonas aeruginosa*). Non-PPMs are micro-organisms of the oropharyngeal and gastrointestinal flora, which do not cause infection in nonimmunosuppressed patients (*e.g. Streptococcus viridans*, *Neisseria* spp., *Corynebacterium* spp., *Candida* spp.).

The histological findings of the lung tissue were classified into five categories: 1) postobstructive changes: chronic inflammation and desquamative alveolar damage, without fibrosis; 2) fibrosis: presence of connective tissue and collagen; 3)

lymphangitis: neoplasic infiltrate of the lymphatis; 4) granuloma: foci of giant cells without necrosis; 5) pneumonia: neutrophilic infiltration in the alveoli. After bronchoscopy, each patient received prophylactic antibiotic treatment according to hospital policy (*i.v.* cefazoline 1 g ×3, or clindamycin 300 mg ×4, for 48 h).

Statistical analysis

Data processing and analysis were performed using the SPSS 10.0 for Windows (SPSS, Chicago, IL, USA). The results are expressed as percentage and mean±SD. Continuous variables were compared using a nonparametric test (Mann-Whitney, U-test) and the categorical variables by Chi-squared or the Fisher exact test, as appropriate. The level of significance was set at 5%. Logistic regressions were performed to evaluate the risk factors associated with bronchial colonization and the risk factors associated with postoperative infective pulmonary complications. Variables with a $p<0.10$ in one univariate analysis were included in the multivariate analysis.

Results

Patient characteristics

Of the 142 patients with lung cancer admitted to the Dept of Thoracic Surgery during the study period, only 41 complied with the inclusion criteria. All the other patients were excluded because of previous antibiotic treatment (in the preceding 4 weeks) or refusal to participate in the study. The main characteristics of the patients are summarized in table 1.

Tumour location was central (accessible by bronchoscopy) in 15 cases (37%) and peripheral in 26 patients (63%).

Prevalence and pattern of bronchial colonization

The PSB and lung tissue cultures showed a total of 23 strains (21 PPMs and two non-PPMs, corresponding to 10 different species) in 17 (41%) of the 41 patients. Of the 10 different species isolated, eight were PPMs while two were non-PPMs. The PPMs isolated were: eight *H. influenzae*, three *S. pneumoniae*, three *Pseudomonas* spp., two *M. catarrhalis*, two *S. aureus*, one *Enterobacter* spp., one *Mycobacterium gordonae* and one *Eikenella corrodens*. The non-PPMs isolated were: one *S. viridans* and one plasma coagulase-negative *Staphylococcus* (table 2). When considering PSB cultures alone a total of 20 strains were identified in 16 patients (39%). Resection lung samples of the 41 patients showed only three strains in the cultures (13% of all isolated strains; *M. gordonae*, *E. corrodens* (10^2 cfu·ml^{-1} in both tumour and non-tumour lung samples) and coagulase-negative *Staphylococcus* (10^2 cfu·ml^{-1} in tumour), which were not recovered in PSB samples, giving an additional airway colonization rate of 2%.

Table 2. – Micro-organisms isolated in protected specimen brush (PSB) and biopsy samples

Micro-organisms	PSB	Biopsy	n (%)
PPMs			
Haemophilus influenzae	8		8 (35)
Streptococcus pneumoniae	3		3 (13)
Pseudomonas spp.	3		3 (13)
Moraxella catarrhalis	2		2 (9)
Staphylococcus aureus	2		2 (9)
Enterobacter spp.	1		1 (4)
Mycobactenum gordonae		1	1 (4)
Eikenella corrodens		1	1 (4)
Non-PPMs			
Streptococcus viridans	1		1 (4)
Staphylococcus Coagulase-negative		1	1 (4)
Total	20	3	23

Data are presented as n or n (%). PPMs: potential pathogenic micro-organisms; Non-PPMs: nonpotential pathogenic micro-organisms.

Twelve patients (70%) had airway colonization with one micro-organism and five (30%) with two or more micro-organisms (table 3). Bilateral PSB sampling showed the following results: of the 41 patients three (7%) had bronchial colonization only on the side of the tumour, four (10%) had only colonization of the contralateral lung (opposite the tumour) and in eight (20%), colonization was bilateral. In the last group, of the 41 patients, six (14%) showed the same micro-organism on both sides and two (5%) had a different colonization profile.

None of the isolated strains was resistant to the usual antibiotics (table 3), except for one oxacillin-resistant strain of *S. aureus* and two β-lactamase positive strains of *H. influenzae* and *M. catarrhalis*, respectively (both isolated in the same patient). No multiresistant micro-organism was found.

Histological findings

Histological examination of the post-tumoural tissue was performed in all 41 patients. No pathological findings were seen in 21 patients (52%), postobstructive changes were seen in 15 cases (35%), fibrosis in two cases (5%), granuloma in two cases (5%) and lymphangitis in one patient (3%). Of the 17 patients with airway colonization, seven (41%) showed no pathological findings, eight (47%) had postobstructive changes, one patient (6%) had granuloma and one patient (6%) had lymphangitis. In the patient with histological granuloma as seen in the lung samples, no mycobacteria were isolated from their respiratory samples.

Risk factors for bronchial bacterial colonization

In the univariate analysis, airway colonization by PPMs was considered as the dependant variable, with potentially predictive variables being: age (>65 yrs),

Table 3. – Microbial investigation in patients undergoing surgical resection for lung cancer

Case number	PSB pre-obstructive area	cfu·mL^{-1}	Antibiotic sensitivity	PSB contralateral	cfu·mL^{-1}	Antibiotic sensitivity
4	*P. fluorescens*	10^2	Ci, A, I			
	P. putrida	10^2	Ci, A, I			
11	*Enterobacter*	10^2	#	*Enterobacter*	10^2	#
13	*H. influenzae*	10^2	BP	*H. influenzae*	10^4	BP
	M. catarrhalis	10^2	BP	*M. catarrhalis*	10^4	BP
21						
24				*S. viridans*	10^2	
25	*H. influenzae*	10^2	BN, AS	*H. influenzae*	10^2	BN, AS
	S. pneumoniae	10^2	P, E			
26	*M. catarrhalis*	10^2	BN, AS	*M. catarrhalis*	10^2	BN, AS
27	*S. aureus*	10^2	OR, VS	*S. aureus*	10^2	OR, VS
	H. influenzae	10^2	BN, AS			
28	*S. pneumoniae*	10^6	P, E, C	*S. pneumoniae*	10^2	P, E, C
30				*H. influenzae*	10^2	BN, AS
31	*H. influenzae*	10^2	BN, AS	*H. influenzae*	10^2	BN, AS
32	*H. influenzae*	10^4	BN, AS	*H. influenzae*	10^5	BN, AS
34		10^5		*H. influenzae*	10^3	BN, AS
37				*Pseudomonas* spp.	10^2	Ci, A, I
38	*H. influenzae*	10^3	BN, AS			
40				*S. aureus*	10^2	OR, VS
41	*S. pneumoniae*	10^5	P, E			

cfu: colony forming units; PSB: protected specimen brush; Ci: ciprofloxacin-sensitive; A: amikacin-sensitive; I: imipenem-sensitive; *P. fluorescens*: *Pseudomonas fluorescens*; *P. putrida*: *Pseudomonas putrida*; *H. influenzae*: *Haemophilus influenzae*; BP: β-lactamase positive; *M. catarrhalis*: *Moraxella catarrhalis*; *S. viridans*: *Streptococcus viridans*; BN: β-lactamase negative; AS: ampicillin-sensitive; *S. pneumoniae*: *Streptococcus pneumoniae*; P: penicillin-sensitive; E: erythromycin-sensitive; *S. aureus*: *Staphylococcus aureus*; OR: oxacillin-resistant; VS: vancomycin-sensitive; C: cefotaxime-sensitive. #: not available.

sex (male/female), smoking habits (smokers/exsmokers; >40 pack-yrs), hospitalization during the last year, BMI>25, FEV_1<65%, $D_{L,CO}$<70% and tumour location (central/peripheral). Only two of these variables proved to be statistically significant: BMI>25 (p=0.01) and central *versus* peripheral tumour location (p=0.002). Furthermore, the logistic regression model used to determine the predictors of bronchial bacterial colonization showed that central location of the tumour and increased BMI were independent risk factors for colonization (table 4). Central tumours were associated with a greater risk (OR=9.2, CI (95%)=2.1–39.6, p=0.003) for colonization than peripheral tumours. Increased BMI>25 showed an OR=1.13, CI (95%)=1.2–2.2 (p=0.005).

Postoperative infectious pulmonary complications

Infectious pulmonary complications were observed in five (12%) of the 41 patients, representing 5% of the overall postoperative complications; two (5%) had

Table 4. – Risk factors bronchial colonization

	Colonized patients	Non-colonized patients	OR	CI (95%)	p-value
Univariate analysis					
Age>65 yrs	7 (17)	13 (32)	0.59	0.17–2.1	NS
Sex M/F	16/1 (94/6)	21/3 (87/13)	0.4	0.04–4.6	NS
Smoking habits					
Smokers/exsmokers	9/8 (53/47)	13/11 (54/46)	1.05	0.3–3.6	NS
Pack yrs (>40/>40)	13/3 (81/19)	17/6 (74/26)	1.80	1.34–2.41	NS
Previous hospitalization	1 (6)	0 (0)	0.4	0.2–0.5	NS
BMI>25	13 (76)	9 (37)	5.4	1.3–21	0.01
FEV_1<65%	5 (29)	4 (17)	1.9	0.4–8.8	NS
$D_{L,CO}$<70%	4 (13)	6 (20)	1.0	0.21–4.71	NS
Tumour location					
Central *versus* peripheral	11/6 (65/35)	4/20 (16/84)	9.1	2.1–39.6	0.002
Multivariate analysis					
Central tumour	11 (65)	4 (16)	9.2	2.1–39.6	0.003
BMI>25	13 (76)	9 (37)	1.6	1.2–2.2	0.0047

Data are presented as n (%) unless otherwise stated. OR: odds ratio; CI: confidence interval; NS: nonsignificant; M: male; F: female; BMI: body mass index; FEV_1: forced expiratory volume in one second; $D_{L,CO}$: diffusion capacity for carbon monoxide.

purulent tracheobronchitis and three (7%) had bronchopleural fistulae with empyema. Microbiological investigation was positive in only two of the five cases, showing a positive culture for *H. influenzae* and *S. pneumoniae* in a patient with tracheobronchitis, and *Streptococcus sanguis*, *Enterococcus faecalis* and *Candida albicans* in a patient with fistula and empyema. These micro-organisms did not correspond to those isolated previously in PSB or lung tissue cultures.

Risk factors for infectious pulmonary complications

FEV1<65%, $D_{L,CO}$<70%, BMI<25, age>65 yrs and bronchial colonization were analysed as potential risk factors for postoperative infectious pulmonary complications. None of these variables was significant on univariate analysis (table 5). Bronchial colonization was not a statistically significant predictor of infectious complications.

Discussion

Bronchial bacterial colonization was present in 41% of patients with resectable lung cancer. Potential pathogenic micro-organisms were isolated in all colonized patients with the most frequent being: *H. influenzae* (35%), *S. pneumoniae* (13%), and *P. aeruginosa* (13%). Culture of PSB samples revealed 20 (87%) of the 23 isolated strains while lung tissue culture identified three (13%) of the strains. The risk factors for bronchial colonization were central location of the tumour (OR=9.2) and increased BMI (OR=1.6). The frequency of postoperative infectious pulmonary complications was low (12%) and no relationship with bronchial colonization was observed.

There are few data available in the literature regarding bronchial colonization in patients with lung cancer. Most studies on airway colonization refer to patients with COPD, with rates of bacterial colonization in such cases ranging from 25–83% [6, 7, 10–13]. CABELLO *et al.* [7] also included patients with bronchogenic carcinoma, finding a colonization rate of 42%. In this study, a higher rate of PPMs was found isolated in the PSB samples compared to CABELLO *et al.* [7]. This finding may be related to the previous hospitalization period (3±1 days) in the present series, as the patients observed in CABELLO *et al.* [7] were investigated before admission to the hospital. It is well known that prior hospitalization is a risk factor for abnormal colonization, at least in critically ill patients [14]. Further prospective studies would be required to confirm this hypothesis.

The pattern of bronchial colonization in this study's patients appeared to be similar to that found in patients with chronic bronchitis or in smokers [15], which is not surprising as all of the patients were smokers or exsmokers and 42% had an FEV1<80%. No significant relationship between colonization and obstruction, or the number of pack-yrs was found. However, a population of lung cancer patients were investigated with well preserved lung function and a mean FEV1, which was normal, and this may explain why FEV1 was not a risk factor for colonization.

Lung tissue culture was positive in only three cases (7% of the patients). This finding is consistent with other studies [16, 17], which have reported a low rate of microbial growth in lung tissue in patients with lung cancer. In the study by YUANG-SHUANG *et al.* [16] on the bacteriology of obstructive pneumonitis, the rate of positive culture of postobstructive lung tissue was 12% in nonfebrile patients with lung cancer. The micro-organisms isolated in lung tissue in the study by YUANG-SHUANG *et al.* [16] were all PPMs, corroborating the findings in the present study. Furthermore, a recent study [17] on the bacteriology of cavitating lung tumours showed that only one (7%) of 15 nonfebrile patients had a positive culture of transthoracic aspirate.

Susceptibility tests showed no resistance to the usual antibiotics, except for one strain of *H. influenzae* and one of *M. catarrhalis*, which were β-lactamase positive, and one oxacillin-resistant *S. aureus*. These results are in contrast to other studies that found antibiotic resistance in 32–50% [18, 19] of the patients. This difference could be explained by the fact that most of the patients in the present study had well-preserved lung function while patients in other studies had a significant degree of airway obstruction, associated with severe exacerbation and frequent antibiotic treatment which may have led to antibiotic resistance [20].

Central location of the tumour was an independent risk factor for global bronchial colonization (OR=9.2) compared to peripheral location, probably due to the mechanical bronchial obstruction associated with such tumours. The authors suggest that unilateral

Table 5. – Risk factors for postoperative infectious pulmonary complications (univariate analysis)

	Patients with infectious pulmonary complications	Patients without infectious pulmonary complications	OR	CI (95%)	p-value
FEV1<65%	4 (44)	5 (56)	24	2.2–261	NS
$D_{L,CO}$<70%	3 (30)	7 (70)	8.1	0.7–91	NS
Age>65 yrs	2 (10)	18 (90)	0.6	0.09–4.4	NS
BMI>25	3 (60)	2 (40)	1.3	0.8–7.2	NS
Bronchial colonization	2 (12)	15 (88)	0.9	0.1–6.3	NS

Data are presented as n (%) unless otherwise stated. OR: odds ratio; CI: confidence interval; FEV1: forced expiratory volume in one second; NS: nonsignificant; $D_{L,CO}$: diffusion capacity for carbon monoxide; BMI: body mass index.

obstruction may be a predisposing factor for accumulation of secretions above the obstructed airway and consequent aspiration of colonized secretions to the contralateral lung.

Increased BMI>25 was also an independent risk factor for bronchial colonization, but the OR was small (1.6) compared to tumour location. This finding could be explained by decreased diaphragmatic motility in obese patients, which facilitates the accumulation of bronchial secretions and subsequent microbial growth. There is strong evidence that elevated BMI is also a risk factor for survival in patients with lung carcinoma [21] and for postoperative complications in thoracic, abdominal and vascular surgery [5].

The most common histological findings in regard to postobstruction were chronic inflammatory changes (47% in the colonized patients and 29% in the noncolonized patients). No histological evidence of pneumonia, namely neutrophilic infiltration in alveoli, was found. In fact, none of the patients was febrile at any time and no radiological change was observed during follow-up. As previous studies [16, 17] have shown, pneumonia or lung abscess rarely occur in nonfebrile patients with lung cancer.

Only 12% of the patients developed postoperative infective complications: 5% had tracheobronchitis and 7% bronchopleural fistulae with empyema. No episode of nosocomial pneumonia was observed in these patients, although in the literature the incidence of nosocomial pneumonia in post-thoracotomy patients ranges between 5–22% [3, 22]. The difference may be explained, in part, by effective prophylaxis with cefazoline administered perioperatively and during the following 48 h in all the patients. Another explanation may be that postoperative pneumonias may not have been detected due to the small sample size.

Several risk factors have been reported for postoperative infective pulmonary complications, including FEV_1, low BMI, increased age, active smoking, $D_{L,CO}$<70% and bronchial obstruction [23–25]. In this analysis, no variable was associated with pulmonary complications. Bronchial colonization was not associated with infective pulmonary complications with a similar percentage of pulmonary infections in colonized and noncolonized patients, 12% *versus* 14% respectively. However, a larger sample of patients is needed to assess the potential relationship between bronchial colonization and postoperative pulmonary infections.

In summary, the present study demonstrates that patients with resectable lung carcinoma show a high rate of bronchial colonization (41%), mainly with potentially pathogenic organisms. Independent risk factors for colonization in these patients were central location of the tumour and an elevated body mass index.

References

1. Eickhoff TC. Pulmonary infections in surgical patients. *Surg Clin North Am* 1980; 60: 175–183.
2. Swartz DE, Lachapelle K, Sampalis J, Mulder DS, Chiu RC, Wilson J. Perioperative mortality after pneumonectomy: analysis of risk factors and review of the literature. *Can J Surg* 1997; 40: 437–444.
3. Duque JL, Ramos G, Castrodeza J. Early complications in surgical treatment of lung cancer: a prospective multicenter study. *Ann Thoracic Surg* 1997; 63: 944–950.
4. Galanos AN, Pieper CF, Kussin PS. Relationship of body mass index to subsequent mortality among seriously ill hospitalized adults. *Crit Care Med* 1997; 25: 1962–1968.
5. Bluman LG, Mosca L, Newman N, Simon DG. Preoperative smoking habits and postoperative pulmonary complications. *Chest* 1998; 113: 883–889.
6. Monso E, Ruiz J, Rosell A, *et al.* Bacterial infection in chronic obstructive pulmonary disease. A study of stable and exacerbated outpatients using the protected specimen brush. *Am J Respir Crit Care Med* 1995; 152: 1316–1320.
7. Cabello H, Torres A, Celis R, *et al.* Bacterial colonization of distal airways in healthy subjects and chronic lung disease: a bronchoscopic study. *Eur Respir J* 1997; 10: 1137–1144.
8. Bonten MJ. The role of colonization in the pathogenesis of nosocomial infections. *Infect Control Hosp Epidemiol* 1996; 17: 193–200.
9. Agusti C, Xaubet A, Montón C, *et al.* Induced sputum in the diagnosis of peripheral lung cancer not visible endoscopically. *Respir Med* 2001 (in press).
10. Murray A, Mostafa S, van Saene H. Essentials in clinical microbiology. *In*: Soutenbeek CP, van Saene HKF, eds. Baillieres′s: Clinical Anaesthesiology. 1991; 5: pp. 1–23.
11. Monso E, Rosell A, Bonet A, *et al.* Impacto de la colonizacion bronquial en la calidad de vida del paceinte con bronquitis cronica estable. *Med Clin* 1998; 111: 561–564.
12. Zalacain R, Sobradillo V, Amilibia J, *et al.* Predisposing factors to bacterial colonization in chronic obstructive pulmonary disease. *Eur Respir J* 1999; 13: 343–348.
13. Soler N, Torres A, Ewig S, *et al.* Bronchial microbial patterns in severe exacerbations of chronic obstructive pulmonary disease (COPD) requiring mechanical ventilation. *Am J Respir Crit Care Med* 1998; 157: 1498–1505.
14. Drakulovic MB, Bauer TT, Torres A, Gonzalez J, Rodriguez MJ, Angrill J. Initial bacterial colonization in patients admitted to a respiratory intensive care unit: bacteriological pattern and risk factors. *Respiration* 2001; 68: 58–66.
15. Monsó E, Rosell A, Bonet A, *et al.* Risk factors for lower airway bacterial colonization in chronic bronchitis. *Eur Respir J* 1999; 13: 338–342.
16. Yuang-Shuang L, Pan-Chyr Y, Zeg-Guang W. The bacteriology of obstructive pneumonitis. *Am J Respir Crit Care Med* 1994; 149: 1648–1653.
17. Wei-Yu L, Yuang-Shuang L, Hao-Chien W, Kuan-Yu C, Kwen-Tay L, Pan-Chyr Y. Bacteriology of infected cavitating lung tumor. *Am J Respir Crit Care Med* 2000; 161: 1750–1753.
18. Boldt J, Piper S, Upnus D, Fusle R, Hempelmann G. Preoperative microbiologic screening and antibiotic prophylaxis in pulmonary resection operations. *Ann Thoracic Surg* 1999; 68: 208–211.
19. Miravitiles M, Espinosa C, Fernandez-Laso E, Martos JA, Maldonado JA, Gallego M. Relationship between bacterial flora in sputum and functional

impairment in patients with acute exacerbations of COPID. *Chest* 1999; 116: 40–46.
20. Dewan NA, Rafique S, Kanwar B, *et al.* Acute exacerbation of COPD: factors associated with poor treatment outcome. *Chest* 2000; 117: 662–671.
21. Jatoi A, Daly BDT, Hughes V, Dalial GE, Rcubenoff RA. The prognostic effect of increased resting energy expenditure prior to treatment for lung cancer. *Lung Cancer* 1999; 23: 153–158.
22. Busch E, Verazin G, Antkowiak JG. Pulmonary complications in patients undergoing thoracotomy for lung carcinoma. *Chest* 1994; 105: 760–766.
23. Celis R, Torres A, Gatell JM, Almela M, Rodriguez-Roisin R. Nosoconnial pneumonia: A multivariate analysis of risk and prognosis. *Chest* 1988 93: 1318–1324.
24. Iwamoto K, Ichiyama S, Shimokata K. Postoperative pneumonia in elderly patients: incidence and mortality in comparison with younger patients. *Intern Med* 1993; 32: 274–277.
25. Mitsudomi T, Mizoue T, Yoshimatsu T, *et al.* Postoperative complications after pneumonectomy for treatment of lung cancer: multivariate analysis. *J Surg Oncol* 1996; 61: 218–222.