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Usefulness of Airway Visualization in the Diagnosis of Nosocomial Pneumonia in Ventilated Patients*

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Clinical diagnosis of nosocomial pneumonia in ventilated patients remains a challenge in the ICU as none of the clinical biological and radiologic parameters can predict its diagnosis. To our knowledge, however, the accuracy of direct visualization of the bronchial tree has never been investigated.
Purpose: **To evaluate the interest of airway visualization and to select independent parameters that predict nosocomial pneumonia in ventilated patients.**
Setting: **A ten-bed medical-surgical ICU.**
Methods: **All consecutive patients suspected of having nosocomial pneumonia who underwent bronchoscopy with protected specimen brush, culture examination of BAL, and direct examination of BAL were studied. Clinical and biological data and airways findings were recorded prospectively. Patients were classified as having pneumonia or not according to the results of distal bacteriologic samples, follow-up, and histologic study. Respective accuracies of each variable were calculated using univariate analysis and stepwise logistic regression.**
Results: **Ninety-one patients with suspected nosocomial pneumonia were studied. Patients were randomly assigned to a construction group (n=46) and a validation group (n=45). Using multivariate analysis, 3 factors were associated with pneumonia (a decrease in PaO_2/fraction of inspired oxygen ratio ≥50 mm Hg, odds ratio [OR]=9.97, p=0.026; the presence of distal purulent secretions, OR=7.46, p=0.044; the persistence of distal secretions surging from distal bronchi during exhalation, OR=12.25, p=0.013). These three factors remained associated with pneumonia in the validation group. Interobserver repeatability of the bronchoscopic parameters was good. Having 2 or more of these 3 independent factors was able to predict pneumonia with a 94% sensitivity and a 89% specificity in the construction group and with a 78% sensitivity and a 89% specificity in the validation group.**
Conclusion: **We conclude that direct visualization of the bronchial tree can immediately and accurately predict nosocomial pneumonia in ventilated patients before obtaining definite results of protected samples.** ***(CHEST 1996; 110:172-79)***

Key words: bronchoscopy; nosocomial pneumonia; ventilated patients

Abbreviations: BAL C=culture of BAL fluid; BAL D=direct examination of BAL; cfu=colony forming units; FIO_2=fraction of inspired oxygen; OR=odds ratio; PSB=protected specimen brush

The diagnosis of nosocomial pneumonia in ventilated patients remains a challenge for clinicians in the ICU setting. Lung infiltrates can be associated with nosocomial pneumonia or with various other common pathologic processes such as atelectasis, pulmonary edema, intra-alveolar hemorrhage, lung contusion, or drug reactions.[1] Moreover, none of the classic diagnostic parameters, *ie*, temperature, purulent tracheal secretions, and leukocyte count, are accurate in diagnosing nosocomial pneumonia in ventilated patients.[2]

During the past decade, many diagnostic techniques (protected specimen brush [PSB],[3-5] BAL,[6,7] protected BAL,[8,9] mini lavage,[10] plugged telescoping catheter[11,12]), performed with or without fiberoptic bronchoscopy have been evaluated. Various and controver-

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sial diagnostic values have been described. Directed or blind distal samplings have been compared in some studies and seem to have comparable accuracies.[11,13,14]

To our knowledge, however, the impact of the direct visualization of the bronchial tree in the diagnosis of nosocomial pneumonia has never been investigated. The purpose of the present study is to evaluate the interest of endobronchial viewing in the diagnosis of nosocomial pneumonia in ventilated patients.

Materials and Methods

Study Population

Between September 1992 and January 1994, every patient hospitalized and mechanically ventilated for more than 48 h in a 10-bed medical-surgical ICU was included prospectively in the study when nosocomial pneumonia was suspected. The clinical suspicion of nosocomial pneumonia was based on the appearance of a new and persistent infiltrate during the ICU stay on the chest radiograph, macroscopically purulent tracheal aspirates, and at least one of the following clinical criteria:[15] fever >38.5°C, or hypothermia <36.5°C, leukocytosis (>10×10^9/L), or neutropenia (<4×10^9/L). Patients whose antimicrobials had been changed in the previous 3 days were excluded from the study. When pneumonia was suspected, the following clinical variables were collected on a standardized reporting form: age, simplified acute physiologic score (SAPS),[16] prior antimicrobial therapy, duration of mechanical ventilation, temperature, change in temperature in the previous 2 days, blood leukocytes, blood polymorphonuclear cells and lymphocytes, PaO_2/fraction of inspired oxygen (FIO_2) ratio, its maximum change in the previous 2 days, and radiologic score using the classification of Fagon and coworkers.[5] No patient received new antimicrobials before bronchoscopy.

Study Design

Fiberoptic bronchoscopy was performed for each patient within 12 h of inclusion in the study. Patients were premedicated with fentanyl, midazolam, and pancuronium bromide. Topical anesthetics were never used. Each patient was monitored with a pulse oximeter, and ventilated with an FIO_2 of 1 during the time of bronchoscopy and for 2 h after the end of the procedure. Chest radiograph was performed after each bronchoscopy. Immediately after careful endotracheal aspiration via a sterile tube, the bronchoscope was introduced through a special adaptator (Bodaï Suction Safe; Sontek Medical; Lexington, Mass) and advanced, without suction, to the bronchial orifice of the lung segment identified radiographically as containing the new infiltrate.

The PSB was then inserted into the inner suction channel and advanced to a 3-cm peripheral position before dislodging. The PSB was then removed and placed on a sterile operative field. The bronchoscope was then positioned in the adjacent subsegment and BAL was performed by infusing a total of six 20-mL aliquots of sterile nonbacteriostatic saline solution. The lavage recovered after the first aliquot was discarded and the remaining lavage aliquots were pooled. BAL was considered unavailable when the retrieved lavage fluid was less than 20 mL.

When the fiberoptic bronchoscopy was finished, the specimens were prepared separately as follows:

PSB: Using strict aseptic conditions, the distal portions of the outer and inner cannulas were cleaned sequentially with a 70% alcohol sponge, dried with sterile compresses, and discarded with sterile scissors, distal to the brush so that the brush would not come into contact with the possibly contaminated distal portion of the inner cannula. The brush was then advanced and severed with sterile scissors into numbered screw-capped glass vials containing 1.0 mL of sterile Ringer's lactate solution.

BAL: The pooled lavage fluid was divided in three samples, one for cytologic examination, one for culture examination of BAL (BAL C), and one for direct examination of BAL (BAL D).

The containers were then sent to the laboratory for immediate processing. Microbiologic procedures were performed by experienced technicians, according to the protocol previously described.

Table 1—*Criteria Used to Diagnose Nosocomial Pneumonia in Ventilated Patients*

Criteria for Diagnosis
Definite diagnosis
Presence of nosocomial pneumonia
(1) Positive pleural fluid culture or rapid cavitation of the lung infiltrate associated with the resolution of the clinical and radiologic signs after adapted antimicrobial therapy
(2) Histopathologic diagnosis (*ie,* the presence of consolidation with intense polymorphonuclear leukocyte accumulation in bronchioles and adjacent alveoli involving several adjacent low-power microscopic fields) in autopsies performed within 3 days of bronchoscopy
(3) PSB, BAL culture, and direct examination of BAL fluid recovering greater than or equal to 1,000 cfu/mL, 10,000 cfu/mL, and 5% infected cells, respectively, and absence of recovery without antibiotic treatment
Absence of nosocomial pneumonia:
(4) Full recovery without antimicrobial therapy plus the diagnosis of another disease of the chest accounting for the chest radiograph abnormality
(5) Absence of bacterial pneumonia at autopsy performed within 3 days
(6) Sterile PSB, BAL culture less than 100 cfu/mL, and 0% infected cells in the direct examination of BAL fluid
Uncertain diagnosis
Probable nosocomial pneumonia
(7) The observers thought there was a nosocomial pneumonia
Probable absence of nosocomial pneumonia
(8) The observers thought there was no nosocomial pneumonia

Direct Visualization of the Bronchial Tree

Immediately after the procedure, bronchoscopists (J.F.T., B.M., E.A., B.R.) were asked to complete a standardized reporting form about the aspect of the endotracheal tube (dirty or clean, partly occluded), visual inspection of the first and second division bronchi (erythema, edema, inflammation, obstruction, secretions, abundance, purulence, diffuse, or localized), distal secretions (existence, purulence, localized, or diffuse), and persistence of distal secretions surging to distal bronchi during expiration after careful bronchoscopic aspiration.

As often as possible, using an auxiliary fiberoptic viewer, a second observer was asked to follow the bronchoscopy and to complete the same standardized reporting form independently from the first observer.

Definite Diagnosis

Four diagnostic categories were established before initiating the study: bacterial pneumonia, no bacterial pneumonia, probable bacterial pneumonia, and probable absence of bacterial pneumonia (Table 1).

Statistical Analysis

First Step: Standardized reporting forms were randomized in two groups. Half (construction group) of the reporting forms were used

Table 2—*Characteristics of Patient's Cohort (n=91)

	Pneumonia (n=36)	No Pneumonia (n=55)	p Value
Age, yr	67	65	0.72
Sex, M/F	30/6	36/19	0.06
SAPS	14.2	13.3	0.47
OSF	1.62	1.78	0.16
ARDS, n	11	18	0.72
COPD, n	16	18	0.34
Previous antimicrobials, %†	26	40	0.12
H_2 antagonists, %	23	14.3	0.31
Deaths, %	69	56	0.74
Temperature, °C	38.2	38.1	0.92
Temperature <36.5 or >38.4°C, %	78	75	0.68
Change in temperature >0.5°C, %	70	49	0.044
PaO_2/FIO_2 ratio, mm Hg	205	243	0.13
Decrease in PaO_2/FIO_2 ratio, mm Hg	89.1	25.9	0.000004
Decrease in PaO_2/FIO_2 ratio >49 mm Hg, %	71	31	0.00009
Mechanical ventilation, d	13.5	14.7	0.65
Leukocytes, $\times 10^9$/L	16	16.4	0.82
Increase in leukocytes, >5,000/L	41	29	0.26
Polynuclear cells, $\times 10^9$/L	14	14	0.98
Radiologic score	4.29	4.18	0.81
Diagnostic criteria‡			
1	4	0	
2	2	0	
3	13	0	
2,3	5	0	
1,2,3	3	0	
7	9	0	
4	0	16	
5	0	6	
6	0	18	
4,6	0	7	
5,6	0	3	
8	0	5	

*SAPS=simplified acute physiologic score; OSF=multiple organ system failure.
†There was no change in antibiotic therapy in the previous 3 days before bronchoscopy.
‡See Table 1 for definitions.

to select independent parameters associated with pneumonia, and the other half to validate the results (validation group).

Second Step: Clinical, biological, and fiberoptic findings were then compared in patients with and without pneumonia using χ^2 test, Student's t test, and Wilcoxon's rank-sum test as appropriate. A p value ≤ 0.05 was considered significant. The multivariate analysis was performed using the logistic regression technique.[17] Significant parameters were then introduced in a multivariate model and entered as categorical variables. Continuous variables were dichotomized and coded using one to indicate that a characteristic was present and zero to indicate its absence. All cutoff points were chosen based on the result of the univariate analysis. A stepwise logistic regression was then used for entering new terms into the model with 0.05 as the limit of their acceptance and removal, to select parameters independently associated with pneumonia and to calculate odds ratios (ORs).

Third Step: The data obtained by the multivariate analysis were then tested on the validation group.

Fourth Step: Interobserver repeatability of the fiberoptic parameters and of the score was then assessed by calculating kappa coefficients using cases in which two reporting forms were available.

Since the study did not change our routine practices and involved collection of data without compromising the patient's right to confidentiality, approval by the Institutional Review Board was considered unnecessary.

Results

Patients

During the study period, 402 patients were admitted to the ICU. Two hundred eighty patients were mechanically ventilated for more than 2 days. Nosocomial pneumonia was suspected in 91 cases in 80 patients who were enrolled in the study. The reason for ICU admission was surgical in 39 cases (vascular surgery, n=14; digestive surgery, n=13; other surgery, n=12) and medical in 41 cases (pulmonology disease, n=15; cardiology, n=13; neurology, n=5; other, n=8). Patients had been receiving mechanical ventilation for 14.3 ± 13 days prior to suspicion of nosocomial pneumonia. Twenty-nine (32%) of these patients fulfilled criteria for diagnosis of ARDS and 34 (37%) patients had a history of preexisting COPD. Only two patients were imunocompromised (one HIV-infected patient, one patient with Wegener's granulomatosis).

The definite diagnosis was pneumonia in 27 cases, no pneumonia in 50 cases, probable pneumonia in 9

Table 3—*Characteristics of Probable Diagnosis Cases (n=14)

Patient No.	PSB, cfu/mL	BAL C, cfu/mL	BAL D, %	Bacterias	Other Infection Site	Other Chest Disease	Outcome	Postmortem Histologic Condition	Retrospective Chart Review† No. 1,2,3
1	50,000	100,000	0	PA	Sinusitis, otitis	ARDS, mediastinitis	Dead	Day 10§: no pneumonia	NYY
2	0	100,000	6	HI	No	ARDS, pancreatitis	Alive		NYY
3	0	700	0	PA	Peritonitis	ARDS, peritonitis	Alive		NNN
4	400	0	0	HI	Wound infection	ARDS, pneumonectomy	Dead	Not done	NNN
5	0	30,000	3	HI	*S epidermidis* bacteria	Atelectasis	Alive		YNN
6	50,000	5,000	1	SA	No	Pulmonary edema	Alive		YYN
	50,000	5,000		STP					
7‡	0	40,000	15	N	UTI	Atelectasis?	Alive		YNY
7	0	10,000	27	N	UTI	Atelectasis?	Alive		YNY
8	400	400	0	STP	No	ARDS, pancreatitis	Alive		NNN
	60	100		CNS					
9	40	1,000	0	N	Peritonitis	ARDS, peritonitis	Alive		NNN
10	120	1,200	2	SA	No	Pulmonary edema	Alive		YYY
	10,000	100,000		N					
11	10,000	7,000	0	HI	No	Atelectasis?	Alive		NYY
	100	200		SP					
12‡	50	10,000	0	MM	No	ARDS, pneumonia	Dead	Day 19§: ARDS minimal pneumonia	YYY
	60	2,000		AA					
12	500,000	500,000	1	MM	No	ARDS, pneumonia	Dead	Day 18§: ARDS minimal pneumonia	YYY
	500,000	500,000		AA					

*Every patient was treated with antimicrobial effective on the recovered microorganisms. PA=*Pseudomonas aeruginosa*; HI=*Haemophilus influenzae*; SA=*Staphylococcus aureus*; N=*Neisseria* species; STP=*Streptococcus* species; CNS=coagulase-negative staphylococci; SP=*Streptococcus pneumoniae*; MM=*Morganella morganii;* AA=*Afnia alvei;* UTI=urinary tract infection; Y and N=the observer considered that the patient had (Y) or did not have (N) pneumonia.

†Refer to the opinion of the blind reviewers 1, 2, and 3 concerning the existence (Y) or the absence (N) of nosocomial pneumonia.

‡Patients 7 and 12 underwent 2 bronchoscopies at 24-h intervals before being treated.

§Day n means that death occurred n days after bronchoscopy.

cases, and probable absence of pneumonia in 5 cases (Table 2). Clinical and biological characteristics of patients in each group are presented in Table 2. Only 21 patients with definite pneumonia had the whole positive distal procedures. In the six other definite pneumonia cases, two procedures were positive in four cases and one in two cases. In the probable diagnostic cases, two procedures were positive in seven cases and one in two cases. More details about uncertain diagnostic cases are presented in Table 3. Microorganisms recovered from episodes of pneumonia are shown in Table 4.

Table 4—*Microorganisms Responsible for Episodes of Pneumonia

Microorganism	No.
Staphylococcus aureus	10
Staphylococcus epidermidis	1
Streptococcus pneumoniae	2
Streptococcus species	3
Moraxella catarrhalis	2
Neisseria species	3
Haemophilus species	6
Pseudomonas aeruginosa	7
Acinetobacter baumannii	6
Other Enterobacteriaceae	6
Total (n microorganisms/n episodes)	46/36

*Refer to the microorganisms that were recovered in concentration greater than 10^3 cfu/mL for PSB and greater than 10^4 cfu/mL for the culture of BAL fluid.

There were no deaths during the bronchoscopic procedures. Follow-up chest radiograph demonstrated no barotrauma. No patient experienced a decrease in oxygen saturation below 95% during the procedure. There were no episodes of bronchial hemorrhage requiring local or IV therapy or making BAL impossible.

Construction Cohort

None of the biologic and radiologic criteria used to suspect nosocomial pneumonia were different between the two groups except for the decrease in PaO_2/FIO_2 ratio (Table 5). The appearance of endotracheal tube, trachea, and proximal bronchi was not able to predict pneumonia. Purulent distal secretions and persistence of distal secretions surging to distal bronchi during exhalation were significantly different between the pneumonia and no pneumonia groups (Table 5). Subjective opinion of the bronchoscopist gave five false-positive and five false-negative results.

Using stepwise logistic regression, a decrease of the PaO_2/FIO_2 ratio greater than or equal to 50 mm Hg, the presence of distal purulent secretions, and the persistence of distal secretions surging to distal bronchi

Table 5—*Clinical and Biological Characteristics and Fiberoptic Findings in the Construction Cohort (n=46)*

	Pneumonia (n=18)	No Pneumonia (n=28)	p Value
Temperature, °C	37.8	38.1	0.63
Temperature <36.5 or >38.4°C	83	68	0.25
Change in temperature >0.5°C	66	54	0.39
PaO_2/FIO_2 ratio, mm Hg	185	261	0.06
Decrease in PaO_2/FIO_2 ratio, mm Hg	104	19	0.000004
Decrease in PaO_2/FIO_2 ratio >50 mm Hg, %	83	32	0.0004
Purulent aspirates, %*	72	47	0.09
Leukocytes, $\times 10^9$/L	16	17	0.77
Increase in leukocytes, $>5\times 10^9$/L	44	28	0.28
Polynuclear cells, $\times 10^9$/L	14	14.8	0.80
Radiologic score	4.55	4.39	0.82
Appearance of the tracheal tube			
Clean/dirty	13/5	20/8	0.95
Appearance of the trachea and proximal bronchi			
Erythema (yes/no)	12/6	18/10	0.88
Edema (yes/no)	4/14	10/28	0.24
Proximal secretions (present/absent)	11/7	21/9	0.65
Purulent proximal secretions (yes/no)	8/18	12/16	0.92
Abundant proximal secretions (yes/no)	7/11	4/24	0.06
Appearance of the distal bronchi			
Purulent secretions (yes/no)	15/3	8/20	0.0003
Purulent secretions (absent or localized/diffuse)	13/5	25/3	0.14
Persistence of distal secretions after aspiration (yes/no)	13/5	3/25	0.00003
Bronchoscopist's conclusion			
Pneumonia/no pneumonia	13/5	5/23	0.0003

*Refer to the result of the tracheal aspiration performed by the bronchoscopist immediately before each bronchoscopy.

during expiration remained independently associated with pneumonia (Table 6).

The presence of 2 or more of these criteria is accurate in predicting nosocomial pneumonia with a sensitivity of 94±6% and a specificity of 89±11% (Table 7).

Validation Cohort

The three selected parameters remained significantly associated with pneumonia in the validation cohort. The presence of 2 or more criteria was able to predict pneumonia with a 78% sensitivity and an 89% specificity (Table 7).

Analysis Concerning Definite Diagnostic Cases Only

Using a stepwise logistic regression in the 77 definite diagnosis cases, the 3 parameters remained independently associated with nosocomial pneumonia (decrease of the PaO_2/FIO_2 ratio greater than or equal to 50 mm Hg: OR, 6.61; p=0.017; presence of distal purulent secretions: OR, 6.29; p=0.022; persistence of distal secretions surging to distal bronchi during expiration: OR=20; p=0.0002). The existence of 2 or more

Table 6—*Independent Relationship of the Three Index Predictors to Occurrence of Pneumonia in the Construction Cohort**

	Construction Cohort (n=46) OR (95% CI)	p Value
Decrease in PaO_2/FIO_2 ratio >49 mm Hg	9.97 (1.35-73.7)	0.026
Distal purulent secretions	7.46 (1.07-54)	0.044
Persistence of distal secretion after aspiration†	12.25 (1.74-83.5)	0.013

*See text for statistical methods. CI=Confidence interval.
†Refer to secretion surging from distal bronchi during expiration after careful bronchoscopic aspiration.

Table 7—*Accuracy of Clinical and Fiberoptic Criteria in Predicting Nosocomial Pneumonia in Construction and Validation Cohort**

	Se, %	Sp, %	False-Positive, No.	False-Negative, No.
Construction cohort (n=46)				
Decrease in PaO_2/FIO_2 ratio >49 mm Hg	83	68	9	3
Distal purulent secretions	83	71	8	3
Persistence of distal secretion after aspiration	72	89	3	5
Two or more criteria present	94	89	4	1
Three criteria present	50	96	1	9
Validation cohort (n=45)				
Decrease in PaO_2/FIO_2 ratio >49 mm Hg	56	70	8	8
Distal purulent secretions	78	56	12	4
Persistence of distal secretion after aspiration	67	93	2	6
Two or more criteria present	78	89	3	4
Three criteria present	28	100	0	13

*Se=sensitivity; Sp=specificity.

of these criteria predicted nosocomial pneumonia with an 89±12% sensitivity and an 88±9% specificity.

Repeatability of Fiberoptic Findings

In 27 cases, 2 independent observers reported fiberoptic findings. Agreement about existence of distal purulent secretions occurred in 25 of 27 cases (95%) giving a kappa coefficient of 0.85, and agreement about persistence of distal secretions occurred in 26 of 27 cases (96%) giving a kappa coefficient of 0.92.

Discussion

This prospective cohort study shows that, with a decrease in PaO_2/FIO_2 ratio greater than or equal to 50 mm Hg, 2 fiberoptic findings, *ie,* existence of distal purulent secretions and persistence of secretions surging from distal bronchi after bronchoscopic aspiration, are independent predictors of nosocomial pneumonia in ventilated patients. These parameters were found to be significantly associated with pneumonia in two independent cohorts of patients. The presence of 2 or more of the selected parameters (*ie,* distal purulent secretions, decrease in PaO_2/FIO_2 ratio $\geq$50 mm Hg, persistence of distal secretion after bronchial aspiration) was accurate to predict pneumonia in our unit.

The repeatability of the fiberoptic findings, as assessed by 27 pairs of observations, seems to be good and suggests that these results might be used in other units.

However, these criteria are accurate if patients are paralyzed or sufficiently sedated as the persistence of distal secretion surging during expiration requires a complete inhibition of the cough. A large majority of the cohort studied were not immunocompromised and we think that this scoring system, taking into account purulent secretions, remains to be tested in immunocompromised, especially granulocytopenic, patients.

The definitions used to accept or reject nosocomial pneumonia have been carefully chosen but must be discussed. A recent international consensus conference on the clinical investigation of ventilator-associated pneumonia has defined definite pneumonia with more restrictive criteria:[18] CT evidence of pulmonary abscess or histologic examination cannot be considered without positive culture. These definitions are, of course, not suitable for an ICU population in routine practice. However, in patients in whom we used histologic study, pleural fluid, or cavitation on CT scan, a minimum of one distal sampling was positive using standard thresholds.

For the other definite pneumonia cases, we used the association of three distal samplings (*ie,* PSB, direct examination, and culture of bronchoalveolar fluid). The diagnostic value of the association of two procedures has been demonstrated to be specific in diagnosing pneumonia. In our experience, the association of PSB and BAL D gave 89% specificity.[19] In a recent postmortem study from Chastre and coworkers,[20] the same association accurately predicted nosocomial pneumonia with 91% sensitivity and 89% specificity. In another recent postmortem investigation from Papazian et al,[21] the specificity of PSB, using the 1,000 cfu/mL threshold, in diagnosing pneumonia was 95%. We think that the association of positive PSB, BAL C, and BAL D together with the absence of recovery without antibiotic treatment is highly specific in diagnosing nosocomial pneumonia in ventilated patients.

In the same manner, definite criteria used to exclude nosocomial pneumonia are questionable. We considered that complete recovery without antibiotic treatment and absence of any histologic sign of pneumonia are accurate in predicting the absence of pneumonia.

The results of distal samplings (*ie,* sterile PSB and 0% infected cells in BAL D and less than 100 cfu/mL in BAL C) were also used to reject nosocomial pneumonia. In our experience, no patient whose antibiotic treatment within 3 days of bronchoscopy was unmodified has had nosocomial pneumonia using these definitions.[19] In the study of Papazian et al,[21] the sensitivity of BAL C using a 100 cfu/mL threshold in diagnosing histologic pneumonia was 92%.

The probable criteria we used in 14 patients are more questionable. However, in the nine probable pneumonia cases, two of three distal samplings were positive in seven. Similarly, in the five probable absence of pneumonia, PSB, BAL C, and BAL D were negative using the classic thresholds in four cases and BAL C was the only positive distal sampling in the last one.

Our major problem in elaborating the study design was the patients who cannot be classified because of discordance of distal samplings, other diseases of the chest, or other infectious processes. We used blind retrospective chart reviews. However, the definite diagnosis for these episodes is more questionable. In excluding these episodes, do we not exclude the patients in whom the diagnosis of nosocomial pneumonia is the most difficult? As there is no definite answer to this difficult question, we have chosen to keep them in the first analysis and to perform another analysis excluding them. The results remained unchanged.

Many studies dealing with the diagnosis of nosocomial pneumonia have shown that none of the classic criteria used to suspect nosocomial pneumonia (*ie,* purulent tracheal aspirates, increase or decrease of the WBCs, fever, or hypothermia) are accurate in predicting nosocomial pneumonia in ICU mechanically ventilated patients. In fact, only 30 to 50% of patients suspected of having nosocomial pneumonia really have nosocomial pneumonia. The absence of accuracy of these data in predicting pneumonia is confirmed in the

present study. Many diseases have been associated with such clinical or biological abnormality in ventilated patients.[1] The overtreatment of patients with suspected nosocomial pneumonia exposes them to the use of expensive and ineffective antibiotics, increasing the risk of colonization with potentially multiresistant organisms and leading to unrecognized other conditions that mimic pneumonia.

The cost/benefit ratio of the use of bronchoscopy in the diagnosis of nosocomial pneumonia in ventilated patients has not yet been clearly evaluated. The effect on gas exchange and hemodynamics seems to be modest[22] even in patient with ARDS,[23] except in studies in which patients were not sufficiently sedated or not paralyzed,[12] and most of time related to BAL rather than to bronchoscopy alone.

The use of sedation and short-acting paralytic agents has been recommended in the last international consensus conference to improve tolerance of bronchoscopy in ventilated patients.[24] High intrathoracic pressure in patients not appropriately sedated has been reported and might increase the risk of barotrauma during bronchoscopy.[25] Moreover, distal samplings and especially PSB has been initially validated in sedated and paralyzed patients by the Bichat hospital team.[3,5] If the cough is not completely inhibited, we think that the concentration of microorganisms in the distal secretions and then the concentration of microorganisms recovered by the distal samplings can be modified and then might modify the accuracy of such procedures. Therefore, we think that proper sedation (and perhaps systematic curarization) must be used in every case. We especially used fentanyl and pancuronium bromide because of their current use in French ICUs, but proper sedation with other drugs would have been adequate.

A chest radiograph was obtained systematically immediately after each procedure because of the hypothetical risk of barotrauma. However, using this method, pneumothorax is very rare[5,19] and the cost-benefit ratio of this examination might be considered.

Some authors have compared the accuracy of distal procedures (especially PSB[13,14] and plugged telescoping catheter[11]) performed blindly or using a bronchoscope. These articles concluded that these techniques have a similar accuracy and that a blind distal sampling is cost saving.

Two publications compared the results of PSB obtained from the radiographically involved lung with those of the noninvolved lung with opposite results.[26,27] However, nosocomial pneumonia is frequently multifocal[28] and sampling site might had minor implications on quantitative results of PSB. Moreover, in patients with predominantly left lung infiltrates, nonbronchoscopic sampling is less likely to provide a reliable microbiologic diagnosis as most sampling catheters inserted blindly via the endotracheal tube are directed to the right lung.[28]

Our findings argue for the use bronchoscopy, which is useful in giving accurate arguments for nosocomial pneumonia in ventilated patients. Moreover, these findings are available immediately and might be sufficient to initiate antibiotic therapy using Gram's stain examination of bronchial aspirates before the results of distal sampling cultures available after 24 to 48 h.

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Usefulness of Airway Visualization in the Diagnosis of Nosocomial Pneumonia in Ventilated Patients

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