Diagnostic accuracy of protected catheter sampling in ventilator-associated bacterial pneumonia

F. Bregeon*, L. Papazian[†], P. Thomas[‡], V. Carret[†], L. Garbe[§], P. Saux[¶], M. Drancourt[#], J-P. Auffray[¶]

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ABSTRACT: The aim of this study was to assess the accuracy of protected telescoping catheter performed using: 1) protected distal aspiration, or 2) protected mini-bronchoalveolar lavage for the diagnosis of ventilator-associated bacterial pneumonia.

Twenty-seven patients who died after receiving mechanical ventilation for at least 72 h were included in a comparative prospective post-mortem study. The two microbiological sampling procedures were performed immediately after death. Surgical pneumonectomies and biopsies were performed within 30 min of death at the bedside for histological examination. The results of the two techniques were compared with histological post-mortem lung examination or biopsies.

Histological examination of the parenchyma showed signs of pneumonia in 14 cases. Lung tissue culture was positive in nine of these 14 cases. When ventilator-associated bacterial pneumonia was defined by the association of histological signs and positive lung tissue culture the sensitivity was 78% for both sampling techniques, specificity was 86% for mini-bronchoalveolar lavage and 100% for protected distal aspiration (at a threshold of 1×10^3 cfu·mL⁻¹).

Both techniques protected the distal aspiration and mini-bronchoalveolar lavage, and provided good specificity with an acceptable sensitivity for the diagnosis of ventilator-associated bacterial pneumonia.

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*Laboratory of Physiology, UPRES EA 2201, Université de la Méditerranée, [†]Medical I.C.U., Hôpitaux Sud, [‡]Thoracic surgery, Hôpitaux Sud, [§]Laboratory of Pathology, Hôpitaux Sud, [¶]Medico-Surgical I.C.U., Hôpitaux Sud, and [#]Laboratory of Microbiology, Hôpitaux Sud, Marseille, France.

Correspondence: L. Papazian, Réanimation Médicale, Hôpital Sainte-Marguerite, 13274 Marseille Cedex 9, France, Fax: 33 491745435

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Nosocomial bronchopneumonia occurs frequently in patients requiring mechanical ventilation. It has a high incidence when either clinical or histological criteria are used [1–6]. In ventilated patients, clinical criteria are usually regarded as unreliable because many noninfectious processes can mimic pneumonia or because true cases of pneumonia do not always provide clinical evidence. Therefore, in order to identify cases of ventilator-associated bacterial pneumonia and to determine the bacteria responsible for it, microbiological bronchial sampling techniques are required. An invasive strategy based on bronchoscopic sampling has been proposed by some authors [7–8] but this is time consuming, expensive and can worsen the patients' respiratory status. Moreover, some studies have highlighted the lack of sensitivity and/or specificity [3, 6, 9]. A noninvasive strategy based on blind methods has also been proposed [9–11]. Among noninvasive sampling methods, some authors have proposed a protected telescoping catheter inserted blindly into the respiratory tract in order to avoid contamination of the sample with pathogens from the upper tracheo-bronchial tree [12, 13]. A protected telescoping catheter can be used in two ways, either by simple distal protected aspiration or instillation of sterile saline, *i.e.* protected mini-bronchoalveolar lavage. There is no previous study

that evaluates protected distal aspiration using histology as the reference method, and only one group has evaluated mini-bronchoalveolar lavage [13, 14].

The aim of this work was to evaluate blind protected distal aspiration and blind mini-bronchoalveolar lavage using lung histology and tissue culture as reference tests for the diagnosis of bacterial ventilator-associated pneumonia.

Materials and methods

Patients

Nonimmunosuppressed patients who died after receiving mechanical ventilation for at least 72 h in the Polyvalent ICU of Sainte-Marguerite Hospital in Marseille, France (October 1994–December 1997) were included in the study if: 1) ventilator-associated bacterial pneumonia was suspected, 2) death occurred during laboratory working hours, and 3) the relatives gave written consent (second period of the study). Within 15 min of death, the two microbiological sampling techniques were performed. Thereafter, either entire lung removal or blind lung biopsies were performed.

The following variables were recorded prospectively on admission: age, sex, severity score (APACHE II score) [15], severity of underlying condition according to the criteria of McCABE and JACKSON [16] and reason for admission to the ICU. A radiological classification using the WEINBERG *et al.* [17] score was also recorded.

The presence or absence of a clinical diagnosis of ventilator-associated bacterial pneumonia was evaluated prospectively prior to death. A complete clinical picture of pneumonia was defined as the presence of all the following criteria: chest radiograph showing a new and persistent infiltrate consistent with pneumonia, purulent sputum, elevated temperature $>38.3^{\circ}\text{C}$ or white blood cells (WBCs) count $\geq 10,000$ or $\leq 1,500\text{-mm}^3$ and alteration of gas exchange. A Clinical Pulmonary Infection Score (CPIS) was calculated during the 24 h preceding death according to the criteria of PUGIN *et al.* [18].

The study was approved by the authors Institutional Review Board. In the first period of the protocol (October 1994–March 1995) whole lung removal for histological examination was undertaken according to current French legislation which allowed the removal of organs for scientific research barring express opposition by the patient before death (Law No. 76-1181, December 22, 1976, followed by Statutory Order No. 78-501, March 31, 1978, and the Implementation Order dated April 4, 1978). Following a change in the legislation, the study was suspended for 1 yr. In the second period (April 1996–December 1997), lungs were sampled and studied after family members had given written informed consent according to the new legislation (Law No. 94-653, July 29, 1994 Art. L. 671-9.). Thereafter, family members consented only for biopsies but not for total lung removal. In total, 20 patients were included during the first period, and 7 during the second period.

Respiratory sampling

The two sampling techniques were performed immediately after death without discontinuing mechanical ventilation. The results of the semi-quantitative analysis of sputum allowed calculation of the CPIS score. In order to avoid the spread of diluted secretions resulting from mini-bronchoalveolar lavage, protected distal aspiration was performed first, followed by lavage. Protected distal aspiration was performed *via* a double polyethylene catheter (CombicathTM; Plastimed, Saint-Leu-La-Forêt, France), according to the technique described by PHAM *et al.* [12]. Mini-bronchoalveolar lavage was performed using a double polyethylene catheter (CombicathTM; Plastimed, Saint-Leu-La-Forêt, France) according to the technique described by ROUBY *et al.* [13]. A 20-mL aliquot of normal saline was injected *via* the internal catheter and at least 2-mL was aspirated for microbiological examination.

Microbiological processing

Direct examination was not performed. Two serial 100-fold dilutions were made and 0.1-mL aliquots of the original suspension and each dilution were cultured. Each dilution and original suspension was placed on agar plates

for aerobic and anaerobic culture. Bacterial identification and sensitivity tests were performed by standard methods [19]. Quantitative results of protected distal aspiration and lavage culture were expressed in colony forming units·mL⁻¹ (cfu·mL⁻¹). Qualitative and quantitative cultures were evaluated by both techniques using various thresholds.

Reference method

Pneumonectomy was performed at the bedside within 30 min of death while maintaining mechanical ventilation. Depending on the predominant side of the radiographic infiltration, the right or left lung was removed *via* thoracotomy. If radiographic densities were diffuse, the right lung was removed. One specimen from each lobe (corresponding to an average size of $2 \times 2 \times 2$ cm each), from suspicious areas if present, was cut superficially to avoid bronchial contamination.

When total lung removal could not be performed, open lung biopsies were used to sample the lung parenchyma. A 2-cm lateral thoracotomy incision was made in the fifth intercostal space. A rib spreader and atraumatic graspers were used. One to four biopsy specimens were taken blindly from dependent areas of one or several lobes. Bilateral biopsies were performed if radiographs showed bilateral infiltrates. Specimens were collected aseptically, weighed, and homogenized in peptone broth to obtain a final dilution of 1:10. Serial ten-fold dilutions (1×10^{-2} – 1×10^{-6}) of this material were made and cultured. All bacteria cultured from lung tissue were taken into account whatever the number of colonies.

Histological examination of biopsies or entire lung was performed by an experienced pathologist (LG) with no prior knowledge of the culture results or clinical picture.

Diagnosis of ventilator-associated bacterial pneumonia

Both histological and histologically plus microbiologically-proven ventilator-associated bacterial pneumonia were assessed. Classification of histological pneumonia was determined according to the three grades of severity described by ROUBY *et al.* [14] (focal bronchopneumonia, confluent bronchopneumonia, and lung abscess). Classification of each segment was based on the worst grade observed in that segment. Bronchiolitis was not considered as pneumonia. Histological plus microbiological ventilator-associated bacterial pneumonia was diagnosed by the presence of histological signs of ventilator-associated bacterial pneumonia together with a positive culture of lung parenchyma.

Statistical analysis

All data are expressed as mean $\pm$ standard deviation (SD). Depending on the size of the sample, chi-squared test with Yates correction or Fisher's exact test was used to compare qualitative data. The diagnostic yield of each sampling technique was assessed at different thresholds for the diagnosis of histological pneumonia by calculating the sensitivity, specificity, predictive values, false positive and false negative rates and diagnostic accuracy rate using

standard formulae. The predictive performance of each procedure was evaluated by calculating the area under the Receiver Operator Characteristic (ROC) curve. The area under the ROC curve provides the best index of detectability or discrimination independent of the threshold value [20]. The different areas under the ROC curves were compared using the method described by HANLEY and McNEIL [20]. A p-value <0.05 was considered significant. The degree of concordance between protected distal aspiration and mini-bronchoalveolar lavage was assessed using Kappa coefficients. Kappa values close to 1.0 indicate a high degree of concordance between two methods while values under 0.40 indicate weak or no concordance [21].

Results

Characteristics of the patients

During the two study periods, 140 patients died after at least 72 h of mechanical ventilation in the ICU. Of these 140, 27 fulfilled the inclusion criteria and were included in the study (12 females and 15 males; mean age 66±10 yrs). Histological findings identified 14 patients with and 13 without ventilator-associated bacterial pneumonia. None of the variables or scores recorded on admission differed between the 2 groups except for the clinical suspicion of ventilator-associated bacterial pneumonia in the 24 h preceding death (table 1).

No patient other than number 25 had a change of antibiotic treatment during the three days preceding death (table 2). Fourteen patients had no intravenous antibiotics during the three days before death. Thirteen patients were still receiving antibacterial treatment in the final 24 h (table 2).

Table 1. – Clinical characteristics of the population studied

	Pneumonia	No pneumonia	P-value
Subjects n	14	13	
Age yrs	61.8±8.8	69.3±10.8	NS
Sex M/F	8/6	7/6	NS
Reason for admission to the ICU			NS
Postsurgical status	7	2	NS
Neurological disorder	3	4	NS
Acute exacerbation of COPD	2	3	NS
Lung contusion	1	0	NS
Cardiac insufficiency	1	3	<0.05
Septic shock	0	1	NS
APACHE II on admission	21.4±6.1	24.8±6.6	NS
Prior mechanical ventilation days	16±10	22±21	NS
CPIS*	8.3±1.3	5.4±2.4	<0.01
Complete clinical picture*	14	5	<0.05
Pa _a O ₂ /FiO ₂ mmHg*	148±15	165±73	NS
WBC 1 × 10 ⁹ ·L ⁻¹ *	17.6±8.8	14.5±6.8	NS
Body temperature °C*	38.7±1.0	38.1±2	NS
Radiographic score*	8.1±2.2	7.9±2.1	NS

Results presented as mean±SD. COPD: chronic obstructive pulmonary disease; CPIS: clinical pulmonary infection score; Pa_aO₂: oxygen tension in arterial blood; FiO₂: inspiratory oxygen fraction; WBC: white blood cells. *: recorded prospectively in the 24 hours preceding death.

A total of five patients had previously had ventilator-associated bacterial pneumonia diagnosed by clinical and microbiological criteria. In four of them this had been resolved at the time of the death (they had completed antibiotic treatment and showed clinical resolution and negative bronchial samples at least 3 days before the protocol: patients number: 10, 20, 21 and 24). The remaining patient had shown no real improvement despite antibiotics which were discontinued with the instruction "do not resuscitate" (patient number 16).

Histological examination

Histological analysis of the lung parenchyma was performed in 27 patients. The whole lung was examined in 20 cases, bilateral biopsies in 4 cases and unilateral biopsies in

Table 2. – Clinical status and management of patients

Patient	Duration of MV	Previous VABP days since diagnosis	CPIS	Antibiotics * (days)	Indication for current antibiotics
1	11	-	8	off (3)	
2	8	-	6	on (4)	suspicion of VABP
3	14	-	8	on (14)	meningitis
4	10	-	9	on (8)	suspicion of VABP aspiration
5	14	-	9	on (14)	
6	13	-	9	off	
7	3	-	3	off	
8	56	-	4	off (18)	
9	29	-	9	on (6)	suspicion of VABP
10	76	+ (30 days)	5	off (5)	
11	17	-	4	on (11)	Community-acquired pneumonia
12	26	-	3	off (7)	
13	13	-	8	on (12)	peritonitis
14	22	-	5	off (3)	
15	15	-	7	off (14)	
16	33	+ (27 days)	6	off (12)	
17	6	-	9	off (3)	
18	8	-	5	on (5)	aspiration
19	12	-	5	off (7)	
20	13	+ (30 days)	5	off (7)	
21	21	+ (17 days)	8	off (5)	
22	4	-	7	on (4)	suspicion of VABP
23	7	-	11	on (7)	community-acquired pneumonia
24	35	+ (25 days)	8	on (8)	gastric paresis
25	12	-	3	on (1)	digestive fistula
26	13	-	10	off (6)	
27	20	-	8	on (12)	bacteremia

*: Antibiotics used during the last 24 hours, (duration of antibacterial treatment if "on" and number of days without antibiotics if "off"). VABP: ventilator-associated bacterial pneumonia; MV: mechanical ventilation; CPIS: Clinical Pulmonary Infection Score calculated during the 24-h period preceding death.

3 cases (right side). Histological examination of the parenchyma showed signs of pneumonia in 14 patients (52%). Confluent bronchopneumonia was identified in seven of these 14 cases, focal bronchopneumonia in five and the remaining two patients had lung abscess. Both histology and tissue culture were positive in nine cases (table 3).

Table 3. – Lung and sampling technique culture results and histological grading

Patient	Micro-organisms	Protected distal aspiration cfu·mL ⁻¹	Mini-bronchoalveolar lavage cfu·mL ⁻¹	Biopsy cfu·g ⁻¹	Histo-logical grading
1	<i>Pseudomonas aeruginosa</i>	1 × 10 ³	1 × 10 ³	20	Confluent BP
	<i>Klebsiella pneumoniae</i>	1 × 10 ²	1 × 10 ²	-	
2	-	-	-	-	-
3	<i>Pseudomonas aeruginosa</i>	1 × 10 ²	-	-	Focal BP
4	-	-	-	-	Focal BP
5	-	-	-	-	-
6	<i>Staphylococcus aureus</i>	1 × 10 ⁵	1 × 10 ⁴	2 × 10 ²	Confluent BP
7	<i>Enterobacter cloacae</i>	-	1 × 10 ²	-	-
8	-	-	-	-	-
9	<i>Enterococcus faecalis</i>	1 × 10 ⁴	1 × 10 ⁵	2 × 10 ³	Lung abscess
10	-	-	-	-	-
11	-	-	-	-	-
12	-	-	-	-	-
13	<i>Acinetobacter</i>	1 × 10 ²	1 × 10 ³	-	-
14	-	-	-	-	-
15	<i>Klebsiella pneumoniae</i>	-	-	2 × 10 ³	Lung abscess
16	-	-	-	-	Focal BP
17	<i>Staphylococcus aureus</i>	1 × 10 ⁴	1 × 10 ⁶	1 × 10 ⁴	Confluent BP
18	-	-	-	-	-
19	<i>Enterobacter aerogenes</i>	5 × 10 ²	1 × 10 ⁶	30	-
20	-	-	-	-	-
21	<i>Enterobacter aerogenes</i>	1 × 10 ³	-	+	Confluent BP
22	-	-	-	-	Focal BP
23	<i>Staphylococcus aureus</i>	1 × 10 ³	-	-	Focal BP
	<i>Staphylococcus epidermidis</i>	1 × 10 ³	-	-	
24	<i>Pseudomonas aeruginosa</i>	1 × 10 ³	1 × 10 ⁶	+	Confluent BP
25	<i>Escherichia coli</i>	-	-	+	-
26	<i>Pseudomonas aeruginosa</i>	1 × 10 ³	1 × 10 ³	+	Confluent BP
	<i>Escherichia coli</i>	-	-	+	
27	<i>Escherichia coli</i>	-	1 × 10 ⁴	+	Confluent BP

BP: bronchopneumonia; cfu: colony forming units.

Diagnostic performance of protected distal aspiration cultures

A total of 13 bacteria were detected in cultures obtained from protected distal aspiration samples. If only histological diagnosis was considered, the optimal threshold was 1 × 10³ cfu·mL⁻¹ but this did not provide markedly better diagnostic accuracy when compared to qualitative analysis (table 4). Counts were ≥ 1 × 10³ cfu·mL⁻¹ for nine bacteria, of which seven were also recovered from the lung parenchyma. When histological evidence was combined with a positive culture of the lung to define ventilator-associated bacterial pneumonia, the sensitivity and specificity of protected distal aspiration at 1 × 10³ cfu·mL⁻¹ were 78% and 100%, respectively.

Diagnostic performance of mini-bronchoalveolar lavage cultures

Eleven bacteria were isolated from cultures of mini-bronchoalveolar lavage in the 27 patients. Lavage cultures identified all but three bacteria isolated from the lung cultures and also showed three bacteria that were not present in the lung culture. Counts were ≥ 1 × 10³ cfu·mL⁻¹ for nine bacteria, eight of which were also present in lung parenchyma. The optimal threshold for the diagnosis of histological pneumonia was 1 × 10³ cfu·mL⁻¹ but this did not provide markedly better diagnostic accuracy when compared to qualitative analysis (table 4). When histological evidence and positive lung tissue culture were combined to define ventilator-associated bacterial pneumonia, the sensitivity of mini-bronchoalveolar lavage at the threshold of 1 × 10³ cfu·mL⁻¹ was 78% and the specificity was 86%.

Comparison of the two sampling techniques

No significant difference in sensitivity was observed between protected distal aspiration and mini-bronchoalveolar lavage, whatever the threshold considered (table 4). The concordance between the two techniques was excellent at 1 × 10², 1 × 10³ and 1 × 10⁴ cfu·mL⁻¹ (k coefficient, 0.78, 0.74 and 0.83 respectively). The area under the ROC curve for protected distal aspiration was greater than for lavage but the difference was not statistically significant (fig. 1).

Previous antibiotic therapy and diagnostic performance of protected distal aspiration and mini-bronchoalveolar lavage

Eight patients were being treated with antibiotics at the time of study due to a condition still being present (ventilator-associated bacterial pneumonia, community-acquired pneumonia or aspiration). In seven of these eight patients, protected distal aspiration and mini-bronchoalveolar lavage were concordant. In five of these seven cases the results were concordant with those of histology. When all patients receiving antibiotics during the three days preceding death were considered, the specificity of both techniques was unchanged. However, there was a slight

Table 4. — Operative indices of protected distal aspiration and mini-bronchoalveolar lavage for the diagnosis of histological ventilator-associated bacterial pneumonia

	Sensitivity	Specificity	False positive rate	False negative rate	Positive predictive value	Negative predictive value	Accuracy
Protected distal aspiration							
Qualitative cfu-mL ⁻¹	64	86	14	36	82	69	74
≥ 1 × 10 ²	64	86	14	36	82	69	74
≥ 1 × 10 ³	57	100	0	43	100	68	78
≥ 1 × 10 ⁴	21	100	0	79	100	54	59
≥ 1 × 10 ⁵	7	100	0	93	100	50	52
Mini-bronchoalveolar lavage							
Qualitative cfu-mL ⁻¹	50	77	23	50	70	59	63
≥ 1 × 10 ²	50	77	23	50	70	59	63
≥ 1 × 10 ³	50	86	14	50	78	61	67
≥ 1 × 10 ⁴	36	92	8	64	83	57	63
≥ 1 × 10 ⁵	21	92	8	69	75	52	56

Data are presented as per cent (%) (13 patients without pneumonia and 14 patients with pneumonia).

but nonsignificant decrease in sensitivity of protected distal aspiration for the diagnosis of histological ventilator-associated bacterial pneumonia in patients receiving antibiotics as compared with those not receiving antibiotics during the three days preceding death (71% and 43%). The sensitivity of mini-bronchoalveolar lavage was unaffected by the presence or absence of antibiotic therapy (57% and 43%).

Previous histological lung lesions and diagnostic performance of protected distal aspiration and mini-bronchoalveolar lavage

Eight patients had previously had ventilator-associated bacterial pneumonia (numbers: 10, 16, 20, 21 and 24) or aspiration pneumonia (numbers: 5, 15 and 26), episodes which were different from those at the time of study. Histology showed bacterial pneumonia in five of these. Finally, histology was concordant with protected distal aspiration and mini-bronchoalveolar lavage findings in seven and six cases (88% and 75%) respectively.

Fig. 1. — Receiver Operator Characteristic curves of protected distal aspiration (○; △; □; ◇) and mini-bronchoalveolar lavage (●; ▲; ■; ◆) for the diagnosis of histological ventilator-associated bacterial pneumonia. Each point on the curve indicates the sensitivity and 1-specificity for a particular threshold: 1 × 10²: ○, ●; 1 × 10³: △, ▲; 1 × 10⁴: □, ■; and 1 × 10⁵: ◇, ◆; cfu-mL⁻¹.

Clinical diagnosis

All of the patients studied had at least two clinical criteria of suspected ventilator-associated bacterial pneumonia at the time of death. All of the 14 patients with histological evidence of pneumonia showed the complete clinical picture of pneumonia. This complete clinical picture was present in only five of the other 13 patients despite the fact that all satisfied the radiological criteria (table 2). The reason why 13 of the 19 patients showing the clinical picture of pneumonia did not receive new antibiotics was, a "do not resuscitate" decision in eight patients and the nonavailability of the results of sampling cultures performed during the 48-h period preceding death. Two additional patients (numbers 4 and 23) had been treated for a ventilator-associated bacterial pneumonia diagnosed 8 days previously and cultures performed in the final 48 h were not available at the time of death (table 2).

When compared with the histological diagnosis, the sensitivity and specificity of clinical judgement were 100% and 61% respectively. The CPIS was significantly higher in the pneumonia group. When a threshold of 6 was considered and compared with histological diagnosis, the sensitivity, specificity and diagnostic accuracy of the CPIS was 100%, 69% and 85% respectively.

Discussion

In the present study, the diagnostic performance of protected telescoping catheter sampling and its usefulness when using two different procedures (protected distal aspiration and mini-bronchoalveolar lavage) were evaluated prospectively in comparison with histology and lung tissue culture analysis for the diagnosis of ventilator-associated bacterial pneumonia. The results show a very good concordance between the two techniques which were both specific and had good sensitivity in their ability to recover organisms from lung parenchyma.

Bronchoscopic methods used for the microbiological diagnosis of ventilator-associated bacterial pneumonia have several limitations: they are expensive, require specific equipment and qualified personnel, and should not be performed in the presence of severe hypoxaemia

[22]. Their accuracy for the diagnosis of ventilator-associated bacterial pneumonia has been challenged recently in several studies that also show that noninvasive blind methods can be as accurate [12, 23, 24]. Blind protected telescoping catheter avoids contamination by the upper tracheobronchial tree and thus could improve specificity in comparison with other blind methods. Nevertheless, to the best of the authors knowledge, protected telescoping catheter and its two sampling procedures, aspiration and lavage, have not been previously compared for the diagnosis of ventilator-associated bacterial pneumonia with histology as the reference test.

According to the well-demonstrated heterogeneity of the lung tissue bacterial burden [5, 9, 25], the first Consensus Conference on the clinical investigation of ventilator-associated bacterial pneumonia [26] recommended tissue examination and not culture for the evaluation of diagnostic techniques. Nevertheless, it must be kept in mind that a sampling technique is supposed to sample bacteria from the distal lung area. Therefore, protected telescoping catheter was evaluated in comparison with both histological ventilator-associated bacterial pneumonia and histological plus microbiological ventilator-associated bacterial pneumonia.

The use of antibiotic therapy is a real problem in evaluation of the diagnostic accuracy of microbiological methods as it should induce negative results. Most ICU patients receive antibiotics and it is difficult for ethical reasons to suspend antimicrobial treatment in pre-mortem patients when clinically they are suspected of having ventilator-associated bacterial pneumonia. Despite the fact that in the present study eight patients were classified "do not resuscitate" and were off antibiotics, the role of antibiotics could not have been totally eliminated. However, they probably made only a minor contribution. Only five of the 14 patients with histological pneumonia had negative lung tissue culture but four of these five were receiving intravenous antibiotics at the time of study. It should be noted that one of these four patients had received intravenous antibiotics for 14 days because of meningitis (patient number 3). Therefore, the pathogens responsible for the recent pulmonary infection should have been resistant and growth should have been possible in culture (which was true for protected distal aspiration). The second patient treated with intravenous antibiotics had clinical signs of severe ventilator-associated bacterial pneumonia, suggesting a new episode that had developed despite antibiotic therapy, probably caused by resistant bacteria, and once again, available for culture. Two additional patients were being treated for a recent lung infection.

The results of the present study confirm those of ROUBY and co-workers. [13, 14] for mini-bronchoalveolar lavage and give new information concerning protected distal aspiration. The study of PHAM *et al.* [12] which was performed to validate protected distal aspiration, had the advantage of targeting a large population of ventilated patients whose outcome was representative of ICUs (51% survivors). Nevertheless, the reference diagnosis in this work was in part based on the results of the method that was evaluated (in association with the results of protected specimen brush cultures). Using such reference diagnosis, the authors reported a sensitivity of 100% and a specificity of at least 88% when protected distal aspiration showed at least one micro-organism at a concentration of

$\geq 1 \times 10^3$ cfu·mL⁻¹. Considering the number of false negatives related to protected specimen brushing, the sensitivity of protected distal aspiration should have been overestimated in their work. With histological plus bacteriological reference, a sensitivity of 78% was found at the same threshold. The data in the present study, on the specificity at this threshold is in agreement with the above authors (83–100%).

Clinical diagnosis is commonly inaccurate in recognizing ventilator-associated bacterial pneumonia [3, 27, 28]. In the present work, all of the 14 patients with histologically proven ventilator-associated bacterial pneumonia showed the complete clinical picture of ventilator-associated bacterial pneumonia before death compared with five of the 13 patients without histological evidence. The low specificity limits the value of clinical criteria alone and treatment should be guided by culture results.

Conclusions

Using a histological post-mortem method, the results showed that protected telescoping catheter can be of diagnostic value for bacterial pneumonia acquired in ventilated patients. It has high specificity which is not the case when clinical judgment alone is used. For some clinicians, specificity is of major importance as it can limit antibiotic misuse which has an economic and ecological impact. Therefore, the technique could be proposed as an alternative to protected specimen brushing and bronchoalveolar lavage performed under fibrescopy. Moreover, it could be performed in addition to a less specific sampling technique such as endotracheal aspirate. This could be especially useful when a positive ($\geq 1 \times 10^4$ – 1×10^6 cfu·mL⁻¹) endotracheal aspirate is associated with an incomplete clinical picture.

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