Accuracy of diagnostic tools for the management of nosocomial respiratory infections in mechanically ventilated patients

A. Torres

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ABSTRACT: This article reviews the medical literature concerning available diagnostic tools for managing nosocomial respiratory infections in mechanically ventilated patients. The first part deals with the reliability of the clinical criteria used in diagnosing nosocomial pneumonia in such patients and the accuracy of simple markers of pneumonia such as elastin fibres stain and antibody-coated bacteria. The second part reviews the presently available non-invasive and invasive methods for diagnosing pulmonary infections acquired during mechanical ventilation. With regard to invasive methods, protected specimen brush and bronchoalveolar lavage are extensively discussed in view of the different results in the literature. At the present time, these two methods seem to be the most accurate techniques available. The fact that bronchoalveolar lavage may combine the cytological examination and the quantitative culture of the sample obtained is noted. The role of percutaneous lung needle aspiration is also mentioned. Finally, histological diagnosis of pneumonia and pulmonary postmortem biopsy cultures are reviewed as "gold-standard" reference methods for investigation in this field. Future directions for further clinical research are addressed.

In mechanically ventilated (MV) patients, pulmonary infections are common. The incidence of nosocomial pneumonia acquired during mechanical ventilation has not been well established and it ranges between 9-60% [1-7]. When a ventilator-associated pneumonia develops, the microbiological diagnosis of the pulmonary infection is crucial in order to provide an adequate antibiotic treatment and to avoid unnecessary chemotherapeutic regimens. Unfortunately, the clinical and bacteriological diagnosis of these pneumonias is difficult for a number of reasons. Firstly, common clinical symptoms and signs of pneumonia may be unreliable. A 30% rate of false-positives and false-negatives has been reported [4, 7]. Secondly, the upper airways of intubated patients are universally colonized by Gram-negative bacilli and other microorganisms [5]. This colonization leads to a contamination of simple methods of diagnosis such as endotracheal aspiration or fibroptic bronchoaspirates. Finally, MV patients with pulmonary infections have often had previous antibiotic treatment; this decreases the specificity and the sensitivity of the different diagnostic methods employed [8]. In view of these difficulties, several non-invasive and invasive diagnostic techniques have been developed in recent years in order to improve diagnostic accuracy [8-12]. In the present article, we review the diagnostic value of the methods currently available for diagnosing nosocomial pulmonary infections in MV patients.

Clinical diagnosis

Several clinical criteria have been proposed to diagnose nosocomial pneumonia in MV patients. JOHANSON et al. [5] defined pneumonia when patients presented the following criteria: 1) fever; 2) leucocytosis; 3) purulent tracheobronchial secretions; and 4) the appearance of new and progressive infiltrates in the chest X-ray. Subsequently, CRAVEN et al. [6] added to these criteria the existence of a sputum Gram stain showing more than 25 leucocytes and fewer than 10 squamous epithelial cells per low-power field with recovery of a potential respiratory pathogen. Center for Disease Control (CDC) definitions for nosocomial pneumonia diagnosis [13] combine the use of clinical, radiographic and microbiological criteria. However, it is important to note that some of the clinical criteria
defined by the CDC are of little practical use, e.g.,
rules or dullness to percussion on physical examination
of the chest, and are non-specific in mechanically
ventilated patients.

Despite attempts at establishing dependable clinical
criteria for diagnosing nosocomial pneumonia in
MV patients, recent research has demonstrated lack
of reliability. For example Fagon et al. [7] showed that
neither fever nor leucocytosis (or leucopenia) were
significantly more frequent in a group of MV patients
with pneumonia when compared to MV patients
without pulmonary infection. In addition, purulent
endotracheal secretions present in MV patients,
whilst possibly due to pneumonia, may instead by the
consequence of purulent bronchitis. The
appearance of new pulmonary infiltrates on the chest
X-ray may be caused by other factors such as atelecta-
sis, pulmonary oedema, pulmonary haemorrhage or
pulmonary drug reactions. Other researchers [4, 7–9,
14] have all found a significant percentage of
false-negative or false-positive results using clinical
criteria. In a recent study Fagon et al. [7] analysed 16
clinical variables that may predict ventilator-associated
pneumonia but could not find a combination distinguishing
patients with bacterial pneumonia from those
without.

Two important conclusions ensue from these investi-
gations. Firstly, clinical criteria fail to accurately
diagnose pulmonary infection in MV patients, since
ventilator-associated pneumonia may be easily
misdiagnosed or overdiagnosed. Secondly, it is
necessary to find a simple marker that will facilitate the
diagnosis of ventilator-associated pneumonia, especially
in adult respiratory distress syndrome (ARDS) patients.
The low reliability of clinical criteria in detecting
pneumonias during mechanical ventilation has necessi-
tated the investigation and utilization of invasive
and non-invasive techniques for the diagnosis of these
pulmonary infections in ventilated patients.

Non-invasive techniques

Although aspiration through the endotracheal tube
or tracheostomy is the simplest non-invasive technique
for obtaining pulmonary secretions for microbiological
culture, its usefulness in diagnosing nosocomial
pneumonia in MV patients has yet to be firmly
established. Two reports from our group [10, 11]
comparing qualitative cultures of endotracheal
aspirates to quantitative cultures of protected specimen
brush (PSB) and bronchoalveolar lavage (BAL) sam-

ple5 concluded that endotracheal aspiration was non-
specific (specificity 20–30%) in diagnosing
ventilator-associated pneumonia. Some studies are
consistent with these findings [12, 15], although others
have reported different results. For instance, KasiAN
et al. [16] showed that endotracheal aspiration samples
taken immediately after intubation were useful in 11
out of 14 children with a pulmonary infection. GreIl et
al. and Brun-Buisson [17, 18], using protected and distal
aspirate sampling, have had satisfactory results in
diagnosing ventilator-associated pneumonias. 
Bagelman et al. [19] found no advantages in culturing
PSB samples over routine tracheal suctioning
cultures.

Few studies investigating the diagnostic value of
endotracheal aspirates using quantitative cultures
have been carried out. In addition the results of these
studies have been quite inconsistent. Borderon et al.
[20] found no agreement between quantitative cultures
of endotracheal aspirates and quantitative cultures
of lung biopsies taken immediately after death (taking
10^6 colony forming units (CFU) ml^-1 as cut-off point).
In a more recent study PAPAZIAN et al. [21], comparing
blind distal bronchial sampling to PSB quantitative
cultures, found an excellent agreement between
both techniques (the cut-off point for both methods
was estimated at 10^4 CFU ml^-1). Our group [22] found
no correlation between quantitative cultures of endotra-
cheal aspiration (taking 10^4 CFU ml^-1 as a cut-off point)
and quantitative cultures of PSB and BAL. However,
a preliminary study [23] involving 16 patients with
definite pneumonia, having undergone previous
antibiotic treatment, and 23 control MV patients
without pneumonia, suggests that quantitative cultures
(using 10^5 CFU ml^-1 as cut-off point) of endotracheal
aspirates may have a similar diagnostic accuracy to
that of PSB and BAL.

The large discrepancies in the reported results may
be due to several factors: 1) heterogeneity among
populations studied; 2) differences among the criteria
of pneumonia used; 3) lack of reliable control
groups; and 4) effects of previous antibiotic therapy.
For these reasons, we believe that further studies
comparing endotracheal aspirate cultures to "gold
standard" techniques such as pulmonary biopsy are
needed to determine the usefulness of endotracheal
aspirate cultures for the microbiological diagnosis of
nosocomial pneumonia in MV patients.

Recently, there has been much concern about
finding accurate makers of pneumonia. Salata et al.
[24] prospectively investigated 51 intubated patients
with sequential examinations of tracheal aspirates for
graded Gram stains, quantitative cultures and elastin
fibres. Higher grade Gram stain for polymorphonuclear
cells and bacteria was seen in patients with pneumonia,
but a significant degree of overlap was present.
Quantitative tracheal aspirate colony counts were also
greater in patients with pulmonary infection and
correlated with the Gram stain grading. A colony
count ≥10^3 CFU ml^-1 was seen in the majority of
patients with pneumonia, but also in 40% of patients
without pulmonary infection. The presence of elastin
fibres (stained with KOH, see fig. 1) in the endotra-
cheal aspirate was highly specific for the presence of
necrotizing pneumonia. The technique was not very
sensitive (52%) but very specific (the positive predic-
tive value was 100%). Interestingly, the existence of
elastin fibres preceded the roentgenographic appearance
of pulmonary infiltrates by two days. Despite these
apparently good results, the specificity of elastin
fibres for diagnosis of necrotizing pneumonia in patients with ARDS is much lower [25] and there is no further information about this technique.

According to a study by WINTERBAUER [26] the technique of antibody-coated bacteria has a sensitivity of 73% and a specificity of 98% in the diagnosis of bacterial pneumonia. A clear advantage of this technique is its ability to detect the infection even when quantitative bacterial counts are low due to previous antibiotic therapy. In a study of tracheal aspirates in intubated patients, WUNDBRJK et al. [27] found a sensitivity of 54% and a specificity of 100%. In our experience [28] this technique has an important percentage of false-positive results (30%) when compared to PSB in MV patients.

Blood cultures are theoretically a “gold standard technique”. Unfortunately, the sensitivity is low (around 20%) [29] and the specificity may not be very high in MV patients who may have several primary sources of bacteraemia [30].

**Invasive techniques**

The theoretically low specificity of the cultures of simple endotracheal aspirates and other non-invasive methods have promoted the search for invasive methods to diagnose pulmonary infections in intubated and non-intubated patients. Unlike non-invasive methods, invasive methods permit direct access, thereby facilitating the collection of bronchial and parenchymal tissue and bronchial secretions for sampling.

In intubated patients the bronchoscope has to go through the endotracheal tube and obviously this can easily contaminate the inner channel. To avoid contamination, WINTERBAUER et al. [31] designed a non-protected brushing system with a sterile, single-sheeted, disposable bronchial cytology brush. Quantitative cultures were performed. Twenty nine of the 33 patients with pneumonia had a count above 4x10^3 CFU·ml⁻¹. None of the control group had a count above 3.4x10^3 CFU·ml⁻¹.

**Protected specimen brush**

In order to avoid contamination of oropharyngeal flora, WIMBERLEY et al. [32] developed a PSB system (fig. 2). In vitro [32] and in vivo studies [33-43] have demonstrated that PSB is a highly sensitive and specific method for diagnosing pneumonias in non-intubated patients when quantitative cultures were performed, taking the cut-off point to distinguished colonization from infection at 10^3 CFU·ml⁻¹. Only HALPERIN et al. [44] have found a low specificity of PSB in healthy volunteers infected by rhinovirus. However, these results may be due to an improper PSB sampling methodology.

The PSB technique has some limitations due to its complexity. Liquid lidocaine cannot be used and a high dose of nebulized lidocaine has to be administered (10–15 ml of 4% solution) (only in non-intubated patients). Another limitation is that PSB samples have to be microbiologically processed using quantitative methods. This represents a considerable personnel and material cost for this method. PSB cost itself is relatively high (around 4$ in Spain) and must be taken into account. The remaining requirements for PSB use are summarized in table 1 (adapted from MEDURI [45]).

**Fig. 1.** - Elastin fibres seen in a KOH preparation of endotracheal aspirate sample at an original magnification x400. (Courtesy of Dr J. Puig de la Bellacasa).

**Fig. 2.** - A. Schematic diagram of the protected specimen brush. (Reprinted by permission of publishers Doyma Ed, Barcelona). B. Protected specimen brush prepared for sampling after removing the polyethyleneglycol plug.
and 90% specificity. Similar results were obtained by MOSAIK et al. [46] when they compared PSB to transthoracic needle aspiration and transbronchial biopsy in a ventilated canine model of Streptococcus pneumoniae pneumonia. It should be pointed out, however, that the animal subjects in these two studies had not received previous antibiotic treatment, thus, the results have to be interpreted accordingly. Two of the studies performed in humans [49, 51] were evaluated without quantitative cultures, a prerequisite for an accurate interpretation of PSB results, and it is difficult to compare them with the remaining studies. CRASTRE et al. [8] studied the diagnostic accuracy of PSB in MV patients who died in an intensive care unit [8]. The researchers performed a PSB of the anterior segment of the left lower lobe, shortly after death. This same segment was then removed, quantitatively cultured and histologically processed. These authors confirmed $10^7$ CFU·ml$^{-1}$ as the cut-off point to distinguish colonization from infection. In patients who had undergone previous antibiotic therapy the specificity of PSB cultures using the said cut-off point was 42%. The same group evaluated the PSB in a group of 147 MV patients suspected of having pneumonia [1]. They demonstrated a high negative predictive value of PSB and a 75% positive predictive value using the cut-off point of $10^3$ CFU·ml$^{-1}$. BAUGHERMAN et al. [50] performed a bilateral PSB in MV patients and found concentrations greater than $10^3$ CFU·ml$^{-1}$ in areas with pneumonia. In PSB samples from unaffected areas microorganism consistently grew in concentrations below the cut-off point.

Because bronchoscopy is not always available in an intensive care setting, it is useful to have nonbronchoscopic methods available for guiding PSB sampling in MV patients. ZUCKER et al. [52] studied the blind use of PSB in intubated patients. Using PSB cultures obtained in this way, these authors had an 81% success rate in making decisions concerning antibiotic selection. Our group [10] found a similar diagnostic value using a blindly guided Métras catheter (fig. 3) (a type of catheter used for bronchography) when compared to PSB via fiberoptic bronchoscopy. The proper placement of the Métras catheter was confirmed in the majority of cases. Other investigators have had similar success in using this technique [53]. The Métras catheter can also be guided fluoroscopically, if needed, as it has radiopaque tip. MARQUEETTE et al. [48] compared the PSB to a single standard biopsy brush occluded with an agar plug. In vitro and in vivo studies produced similar results comparing the two systems. Recently, a new device [54] has been designed to blindly obtain secretions from a bronchial segment. This new system has an evertmg through-lumen balloon that provides sterile access to lower airways. Although commercially available, its reliability has yet to be proved.

Table 1. – Methodology of protected specimen brush (PSB) sampling in intubated or tracheostomized patients

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>Sedation and administration of short acting paralytic agent.</td>
</tr>
<tr>
<td>2.</td>
<td>Avoid the injection of lidocaine.</td>
</tr>
<tr>
<td>3.</td>
<td>Avoid the suction of bronchial secretions through the fiberoptic bronchoscope channel.</td>
</tr>
<tr>
<td>4.</td>
<td>The bronchoscope has to be positioned close the segmental area corresponding with chest X-ray infiltrates.</td>
</tr>
<tr>
<td>5.</td>
<td>Advance the PSB 3 cm out of the distal tip of the bronchoscope.</td>
</tr>
<tr>
<td>6.</td>
<td>Push the inner cannula of the PSB to eject the polyethylene glycol plug into the airways.</td>
</tr>
<tr>
<td>7.</td>
<td>Wedge the brush in the subsegmental area.</td>
</tr>
<tr>
<td>8.</td>
<td>Retract the brush into the inner cannula, the inner cannula into the outer cannula and remove the PSB from the bronchoscope.</td>
</tr>
<tr>
<td>9.</td>
<td>Once the PSB is out of the bronchoscope, the distal portion of the inner cannula has to be wiped with a 70% alcohol solution.</td>
</tr>
<tr>
<td>10.</td>
<td>The brush has to be advanced and cut with sterile scissors into a sterile solution containing 1 ml of ringer-lactate.</td>
</tr>
<tr>
<td>11.</td>
<td>The tube with the PSB and ringer-lactate needs to be submitted immediately to the microbiology laboratory for quantitative bacteriological processing.</td>
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</table>

(Fig. 3. – Protected specimen brush inside the inner channel of a Métras catheter. The Métras catheter has a radiopaque tip that can direct the protected specimen brush using a fluoroscopic system.)

In light of the literature concerning PSB, we conclude that this technique is a reliable method for diagnosing nosocomial pneumonias in MV patients. At the fifth "Conférence de Consensus en Réanimation et Médecine d’urgence" it was agreed that PSB, using $10^3$ CFU·ml$^{-1}$ as a threshold, was the most reliable method to diagnose ventilator-associated pneumonias [55]. However, in our opinion several questions remain to be answered. It seems clear that a negative PSB either rules out a pneumonia or is the consequence of an appropriate antibiotic therapy [1, 8]. The problem emerges with the false-positive results that may be the consequence of a prior antibiotic therapy or the bacterial contamination of lower airways in some patients [56, 57]. Our group [58] studying MV
patients without pulmonary infection who had been treated with antibiotics found a low PSB specificity (50%) using $10^5$ CFU·ml$^{-1}$ as the cut-off point. The specificity reached 100% when the cut-off point was raised to $10^6$ CFU·ml$^{-1}$. In the intensive care setting, the majority of patients receive or have received antibiotic therapy when they develop pneumonia. Thus, with antibiotic treatment, one must keep the possibility of false-positive cultures in mind since antibiotics may promote colonization of lower airways.

Complications of PSB which are very uncommon (<1%) include haemoptysis, haemorrhage and barotrauma. Severe haemoptysis has been described in the presence of bleeding disorders [10].

**Bronchoalveolar lavage**

Bronchoalveolar lavage (BAL) is a well-known bronchoscopic technique used to evaluate pulmonary interstitial diseases as well as to diagnose pulmonary infiltrates in immunocompromised patients [59-61]. It was generally believed that specimens retrieved by lavage had the same problem as fibreoptic bronchoscopic aspirates, i.e. the contamination of the oropharynx and upper airways from bacterial flora. However, the utility of Gram stain and semiquantitative cultures of the fluid retrieved by BAL to diagnose respiratory infections was demonstrated by Thorpe et al. [62] in 92 non-intubated patients. Concomitantly, Kass and Jones [63] reported their results on the use of the quantitative cultures of BAL in non-intubated patients. These two studies established the utility of BAL to diagnose bacterial pulmonary infections and agree that the cut-off point to distinguish colonization from infection should be set at $10^6$ CFU·ml$^{-1}$. In addition, in one of these studies [63] the finding of $\leq 1\%$ of squamous epithelial cells was required for the BAL sample retrieved specificity. The specificity of BAL (using quantitative cultures) has also been well established in non-intubated patients [43] but there is still little clinical experience. Recently Pano et al. [42] compared the bacteriology of bronchiectasis using PSB and BAL, obtaining similar results (the cut-off point of BAL $10^6$ CFU·ml$^{-1}$).

The use of BAL in MV patients is much more controversial. Johanson et al. [64, 65] studied the cultures of tracheal aspirates, BAL, PSB, direct lung aspirates and the histology and microbiology of lung biopsy in 35 baboons after 7–10 days of intubation and mechanical ventilation. The majority of animals were treated with prophylactic intravenous or topical regimens. These authors found that quantitative cultures and bacterial indices of BAL samples showed an excellent correlation with the bacterial concentrations and bacterial indices of the cultures of lung tissue. The bacterial index was obtained as the sum of the logarithmic concentrations of individual bacterial species. BAL showed a slightly lower specificity than PSB but it was clearly more sensitive. Chastre et al. [66] were the first to compare BAL to PSB in MV humans. They concluded that quantitative cultures of BAL had little value in identifying patients with pulmonary infection. However, the finding of more than 25% of intracellular organisms in cells recovered by BAL was a 100% specific marker of pneumonia in MV patients. The same authors [67] later established the cut-off point of intracellular microorganisms to distinguish pneumonia at 5–7% (sensitivity 86%, specificity 96%). Recently, our group [11] compared the utility of BAL and PSB in 34 non-immunosuppressed MV patients suspected of having bacteria pneumonia. Quantitative cultures of BAL showed a good correlation with quantitative PSB cultures. Moreover, bacterial indices of BAL cultures were significantly correlated to bacterial indices of PSB cultures (fig. 4).

![Graph](image)

**Fig. 4.** (taken from [11]). Bacterial concentrations (in $\log_{10}$ CFU·ml$^{-1}$) and bacterial indices of individual microorganisms obtained from the cultures of protected specimen brushes (PSB) and bronchoalveolar lavages (BAL) in 25 patients with nosocomial pneumonia acquired during mechanical ventilation. [ ]: bacterial index; [ ]: individual organisms.
The diagnostic accuracy of BAL and PSB was similar (cut-off points for both techniques 10^4 CFU·mL^(-1)) (BAL: sensitivity 59%, specificity 71%, PSB: sensitivity 59%, specificity 86%). GUERRA and BAUGHMAN [68] studied the efficacy and safety of BAL in 60 MV patients. They found a sensitivity of 60%. BAL cultures obtained from control group patients were always below 10^4 CFU·mL^(-1). Other authors have proposed bronchoscopic [69] and non-bronchoscopic [70, 71] protected BAL for the diagnosis of pulmonary infections in MV patients. GAUSSORGUES et al. [70] used a Swan-Ganz catheter to perform BAL. They compared the quantitative cultures of BAL obtained by this procedure to the quantitative cultures obtained by pulmonary biopsy. In nine cases with histologically proven pneumonia, BAL correlated with biopsy cultures. A protected system to perform BAL using a double telescoping plugged catheter has recently been evaluated in MV patients [71]. The sensitivity of this technique in diagnosing pulmonary infections was 80%, whereas the specificity was 66%. MEDURI et al. [72] published, in abstract form, the effectiveness of BAL sampling through a protected transbronchoscopic balloon-tipped catheter. Using a threshold of 10^4 CFU·mL^(-1), protected BAL was considered an effective tool for diagnosing pneumonia in MV patients. PSB results offered a worse diagnostic value. In table 2 the diagnostic value of BAL results obtained by different authors is shown.

Table 2. — Bronchoalveolar lavage diagnostic accuracy in nosocomial pneumonias acquired during mechanical ventilation

<table>
<thead>
<tr>
<th>Author [Ref.]</th>
<th>n</th>
<th>Sens. %</th>
<th>Spec. %</th>
<th>Cut-off CFU·mL^(-1)</th>
<th>Anthb.</th>
<th>Via</th>
<th>Ref. test</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOHANSON et al. 1988 [64]</td>
<td>19</td>
<td>74</td>
<td>87</td>
<td>NS</td>
<td>Yes</td>
<td>FB</td>
<td>Pulmonary biopsy</td>
</tr>
<tr>
<td>GAUSSORGUES et al. 1988 [70]</td>
<td>13</td>
<td>93</td>
<td>89</td>
<td>NS</td>
<td>NS</td>
<td>Cuffed catheter</td>
<td>Pulmonary biopsy</td>
</tr>
<tr>
<td>CHASTRE et al. 1988 [66]</td>
<td>21</td>
<td>NS</td>
<td>69</td>
<td>10^4</td>
<td>No</td>
<td>FB</td>
<td>PSB quantitative cultures</td>
</tr>
<tr>
<td>GUERRA et al. 1990 [68]</td>
<td>60</td>
<td>60</td>
<td>100</td>
<td>10^4</td>
<td>NS</td>
<td>FB</td>
<td>NS</td>
</tr>
<tr>
<td>ROUBY et al. 1990 [71]</td>
<td>59</td>
<td>80</td>
<td>66</td>
<td>NS</td>
<td>Yes</td>
<td>Double protected catheter</td>
<td>Pulmonary biopsy</td>
</tr>
</tbody>
</table>

Sens. — sensitivity; Spec. — specificity; Anthb. — prior antibiotic therapy; FB — fibreoptic bronchoscope; PSB — protected specimen brush; NS: not specified.

In view of the studies mentioned above, BAL seems to be an alternative to PSB for diagnosing pulmonary infections in MV patients, although clinically it seems that the specificity is slightly worse than that of PSB. The fifth "Conférence de Consensus en Réanimation et Médecine d’urgence" held in Paris in 1989 had not yet recommended the use of quantitative cultures of BAL to diagnose ventilator-associated pneumonia [55], but at that time there was less information available about this technique. The contradictory results between some studies should encourage more research comparing BAL to a "gold standard" technique such as postmortem pulmonary biopsy.

### Percutaneous lung needle aspiration

The diagnostic value of percutaneous lung needle aspiration (PLNA) using ultra-thin needles (25 gauge) is similar to that of PSB [73]. To our knowledge there are no references comparing PLNA to BAL. PLNA has been classically contraindicated in patients undergoing mechanical ventilation because of the risk of barotrauma and, in fact, there are no references using this procedure in humans during artificial ventilatory support. In non-mechanically ventilated patients the rate of pneumothorax is 8% [73]. The rate of this complication in patients undergoing ventilatory support is unknown. BERGER and ARANGO [12] performed this technique in 11 critically ill patients but they did not mention whether patients were MV. Apparently the sensitivity of PLNA in this study was 100%. MOSER et al. [46] investigated the diagnostic value of PLNA in a MV model of Streptococcus pneumoniae pneumonia. They found a sensitivity of 100% and a specificity of 88%. We [74] studied the diagnostic accuracy of...
PLNA (using a 22 gauge needle) in seven critically ill MV patients with pneumonia in whom a PSB did not give a microbiological diagnosis. The sensitivity obtained was 37.5%, keeping in mind that these patients had been treated with antibiotics. Nevertheless, PLNA results were crucial for the outcome of these patients. PLNA during mechanical ventilation is probably less dangerous than had been believed, particularly when using thin needles (22–25 gauge). The new generation of ventilators are able to suspend respiratory cycles momentarily in paralysed patients. Furthermore, extensive consolidations avoid an easy introduction of air into pleural space. Thus, we recommend the use of PLNA in MV patients with extensive and severe pneumonia either when other diagnostic procedures, such as PSB or BAL have not been able to identify the microbiological cause of the pneumonia or when there is no favourable clinical response despite the antibiotic treatment against the microorganisms previously isolated in cultures of the samples retrieved by these techniques (PSB or BAL).

Pulmonary biopsy

Pulmonary biopsy is not a technique to be taken into account for the diagnosis of ventilator-associated pneumonias since other less invasive methods are able to identify the responsible microorganisms with less risk [75, 76]. Nevertheless, histological and quantitative cultures of pulmonary biopsy taken immediately postmortem are considered "gold standard" methods for comparing other techniques, and for this reason are useful in clinical studies. The histological definition of pneumonia is considered when there is accumulation of polymorphonuclear leucocytes in alveoli and adjacent bronchi [77]. The majority of nosocomial pneumonias in MV patients are bronchopneumonias. The histological diagnosis of these bronchopneumonias is based on the presence of consolidation foci spread on the lungs. There are very few studies in humans that have used the histology of the pulmonary biopsy as a "gold standard" reference test [8, 9, 20, 70, 71]. Although these studies have to be considered the most reliable to investigate the diagnostic value of a particular technique, we must keep in mind the bronchopneumonic characteristics of the ventilator-associated pneumonias and the necessity of sampling several sites in all the pulmonary lobes when using pulmonary biopsy as a reference test. More studies using postmortem pulmonary biopsies and necropsy findings are necessary to definitely establish the diagnostic accuracy of the available methods for the diagnosis of pulmonary infections in MV patients.

Conclusion

The diagnosis of nosocomial pneumonias in MV patients is still a matter of controversy. Despite the important amount of information available on this subject, there are still several problems which require solution. It seems clear that clinical criteria are subject to an important percentage of error and that there are no absolutely reliable clinical markers of pneumonia. Other markers such as elastin fibres or antibody-coated bacteria need further clinical investigation. As for the different sampling methods available, PSB seems to have been the most thoroughly studied, although there is very little information about the modifications in its diagnostic value caused by prior antibiotic therapy. Taking into account the fact that the majority of ventilated patients are treated with antibiotics, we believe that the specificity of PSB in these cases is an issue which has yet to be adequately solved. There is also very little information about antibiotic changes induced by PSB results and whether the final outcome of patients is modified or not by using the information provided by this technique. BAL is a promising technique but more clinical studies are needed. Despite the need for further research, the finding of more than 5–7% of intracellular bacteria seems to be a specific marker of pneumonia. In a recent review performed at MacMaster University [78], the authors conclude that a randomized trial of PSB versus an empirical therapy with antibiotics is required. In contrast, the fifth "Conférence de Consensus en Réanimation et Médecine d'urgence" [55] recommended the use of the PSB (using a threshold of 10^4 CFU·mL^-1) and BAL sampling to search for intracellular microorganisms as the methods for diagnosing, and managing nosocomial pneumonias acquired during mechanical ventilation. Our personal view is that quantitative cultures of PSB and BAL are valid tools for diagnosing and managing nosocomial pneumonias in MV patients and their utilization depends on personal experience. Future efforts in investigation have to be directed towards valid and simple techniques of sampling lower airway secretions and also towards determining specific markers of parenchymal pulmonary infection.

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Précision des moyens diagnostiques utilisés pour l’approche des infections respiratoires nosocomiales chez les patients sous ventilation mécanique. A. Torres.

RÉSUMÉ: Il s’agit d’une revue de la littérature médicale concernant les techniques de diagnostic disponibles pour faire face aux infections respiratoires nosocomiales chez les patients soumis à une ventilation mécanique. La première partie concerne la valeur des critères cliniques utilisés pour le diagnostic des pneumonies nosocomiales chez ces patients, et la précision de marqueurs simples de la pneumonie, comme les colorations des fibres élastiques et des bactéries marquées par anticorps. La seconde partie fait la revue des méthodes actuellement disponibles, invasives ou non invasives, pour le diagnostic des infections pulmonaires acquises au cours de la ventilation mécanique. En ce qui concerne les méthodes invasives, la brosse protégée et le lavage broncho-alvéolaire font l’objet d’une large discussion, sur base de différents résultats de la littérature. Actuellement, ces deux méthodes s’avèrent les plus précises de celles qui sont disponibles. Le fait que le lavage broncho-alvéolaire permette de combiner l’examen cyto logique et la culture quantitative de l’échantillon obtenu est souligné. Le rôle de la ponction transcutanée pulmonaire à l’aiguille est également mentionné. Finalement, le diagnostic histologique de pneumonie et les cultures de biopsies pulmonaires post-mortem sont considérés comme les “golden standards” pour les recherches dans ce domaine. Des orientations futures pour des recherches cliniques ultérieures sont également évoquées. Eur Respir J., 1991, 4, 1010–1019.