Thi-Qar Medical Journal (TQMJ): Vol. (28), No. (2), 2024
Web Site: https://jmed.utq.edu Email: utjmed@utq.edu.iq
ISSN (Print):1992-9218 ISSN (Online): 3006-4791

Protected Specimen Brush (PSB) or Bronchoalveolar Lavage (BAL) for Diagnosing Ventilator-Associated Pneumonia

Dr Haval Othman Ali [1], [2] Dr Kawa Wsu Hassan
[1]MD, MBChB, DESA,Swedish board in Anesthesia and Critical Care Medicine, Dep. of Critical Care Medicine, Shar Teaching Hospital, Sulaymaniyah Iraq.
E. Mail: havalothmanali@gmail.com
[2]MD, MBChB, FEBC (Card), FIBMS (Med), Dep. of Cardiology Shar Teaching Hospital Sulaymaniyah Iraq.
E. Mail: Kawahassan79@gmail.com

Abstract

Background: Ventilator-associated pneumonia (VAP) is a common and serious infection in intubated patients, leading to increased mortality, longer ICU stays, and higher healthcare costs. Accurate diagnosis is essential for effective treatment and to prevent antibiotic misuse.

Purpose: This study investigates whether bronchoalveolar lavage (BAL) and protected specimen brush (PSB) yield similar culture results in ICU patients with suspected or confirmed VAP.

Methods: A retrospective study was conducted on ICU patients with VAP at Shar Hospital, Sulaymaniyah, Iraq, from 2020 to 2023. Patients on ventilators for ≥48 hours with new lung infiltrates who underwent both BAL and PSB were included. Spearman's correlation was used to compare culture results.

Results: Out of 56 VAP patients, 20 met inclusion criteria. Bacteria were detected in 48% of BAL and 43% of PSB samples. A significant correlation was found between BAL and PSB results (correlation coefficient 0.846, $p < 0.01$), with 96% agreement in detected agents.

Conclusion: PSB and BAL provide comparable results for diagnosing VAP, but PSB might be preferred due to its specificity and lower risk of procedural complications. Correct BAL technique, involving adequate saline flushing, is essential for accurate results. Further studies should standardize BAL procedures to optimize diagnostic accuracy.

1. Introduction

Ventilator-associated pneumonia (VAP) is the most common infection among intubated or tracheostomized patients on ventilators. Patients on ventilators who develop VAP have a two to four times higher risk for mortality from the infection. VAP also leads to prolonged ventilator support and extended stays in the intensive care unit (ICU), resulting in increased healthcare costs [1]. According to the Centers for Disease Control and Prevention (CDC), VAP is defined as pneumonia in a patient who has been on a ventilator for ≥48 hours [2].

Significant efforts have been made to improve the early and accurate diagnosis of VAP in ICU patients. Diagnosis is crucial for appropriate antibiotic treatment and avoiding unnecessary antibiotics. Strategies that contribute to early accurate diagnosis of VAP are clinically important

because overestimating the likelihood of VAP can lead to inappropriate antibiotic use, resulting in multi-resistant organisms and invasive fungal infection. Conversely, underestimating the likelihood of VAP can lead to under-treatment of serious nosocomial infection and increased mortality. A major obstacle in diagnosing VAP is the lack of a uniform accepted standard [3].

Bronchoalveolar lavage (BAL), which involves flushing sterile fluid into the lungs and then suctioning the fluid for culture, and protected specimen brush (PSB), where a sample is taken with a protected brush via a double-lumen catheter to reduce contamination, are the most common diagnostic methods. These methods have been improved and become more accurate. However, they have limitations, such as antibiotic pre-treatment reducing sensitivity and accuracy, reliance on quantitative cultures requiring 24-48 hours for results, and reducing the chance of early detection and correct antibiotic treatment [4]. Good diagnostic results have been reported from quantitative cultures of BAL fluid or PSB performed via fiberoptic bronchoscopy (FOB) [4].

For diffuse infiltrates, the right middle lobe and lingula of the left upper lobe are typical locations easily accessible for bronchoscopic segmental wedge placement. These areas generally provide good BAL fluid return in supine patients, otherwise, the area with the most lung infiltrate is chosen based on chest X-ray [5].

Despite clinical experience with PSB and BAL, it is still unclear which method should be used in clinical practice. The diagnostic characteristics of the methods for diagnosing VAP are probably similar, with only small differences in sensitivity and specificity. Most clinicians in the USA/EU prefer using BAL rather than PSB for diagnosing bacterial pneumonia because BAL: 1. has slightly higher sensitivity for identifying VAP-causing microorganisms, 2. provides better selection of empirical antibiotic treatment before culture results are available (preliminary results come earlier than PSB), 3. is less hazardous for many critically ill patients, 4. is cheaper, and 5. can provide useful clues for diagnosing other types of infections [6, 7].

In Iraq, there is no uniform standard, and different amounts of lavage fluid are used for BAL. Small amounts of lavage fluid during BAL yield a small fluid return containing only diluted material from the bronchial rather than the alveolar level, leading to false-negative results, especially in patients with severe COPD. In these patients, the diagnostic value of BAL is greatly reduced and PSB is preferred. Therefore, the choice between BAL/PSB may depend on the experience and priority of individual physicians and the underlying disease of the patients [7].

Various protocols are used worldwide for performing BAL. Although standardized methods for performing BAL have been proposed, there is no exact final consensus on BAL fluid volume, whether the first retrieved portion should be discarded, the lavage site, or the technique for applying negative pressure. Nevertheless, BAL fluid must be sufficient to retrieve a diagnostically useful amount [5].

2. Research Objectives

The purpose of this study was to investigate whether BAL and PSB provide the same culture results in ICU patients with suspected and confirmed VAP.

3. Methodology

3.1. Design: This study was a retrospective cohort study of patients on ventilators diagnosed with VAP in the ICU at Shar Hospital in Sulaymaniyah city.

3.2. Selection: All patients treated in the Shar hospital ICU with confirmed and/or suspected VAP over a 3-year period (from 2020 to the end of 2023). The selection was based on previous statistics from Shar hospital ICU.

3.3. Inclusion Criteria:

1- Treated with invasive ventilation for ≥ 48 hours
2- Developed a new or progressive lung infiltrate (chest X-ray or CT scan)
- Diagnosed as VAP according to CDC definitions
3- Underwent FOB for VAP diagnosis

3.4. Exclusion Criteria:

1- Patients who did not undergo both BAL and PSB
2- Patients under 16 years old

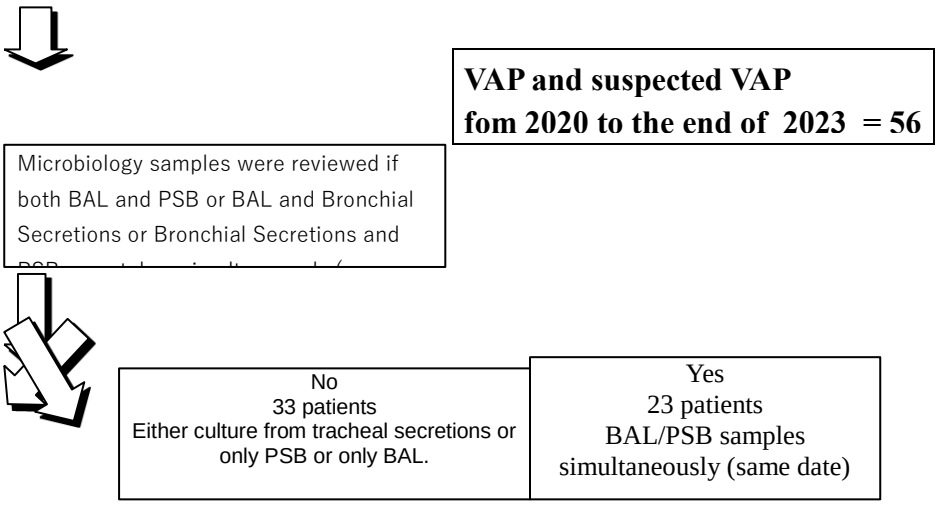
3.5. Procedure: Included patients' medical records were reviewed for the following parameters: age, gender, ongoing antibiotic treatment, ventilation time at sampling, sampling method (BAL/PSB), fluid volume (for BAL), and culture results (type of agent and concentration in cfu/ml).

3.6. Data Analysis: Spearman's test was used to study possible correlations between BAL and PSB cultures. Spearman's correlation coefficient is a non-parametric test that shows the relationship between two variables, in this case, the relationship between quantitative cultures of BAL vs. PSB. A p-value > 0.05 was considered significant.
Statistical analysis was done using SPSS.

3.7. Ethical Aspects: The study aimed to achieve improvements within the Anesthesiology/Intensive Care department at Shar hospital ICU. Before reviewing the records, permission was sought from the department head for anesthesiology and intensive care and hospital director. No personal data will be saved.

4. Results

4.1. Description of the Population: A total of 56 patients with confirmed or suspected VAP were found during the inclusion period. Of these, 33 patients who had not undergone both BAL and PSB were excluded. The remaining 20 patients were included in the study. Three patients were excluded due to the operator sending the wrong referral or taking only bronchial secretions. See Figure 1 for a flow chart of inclusion and exclusion.



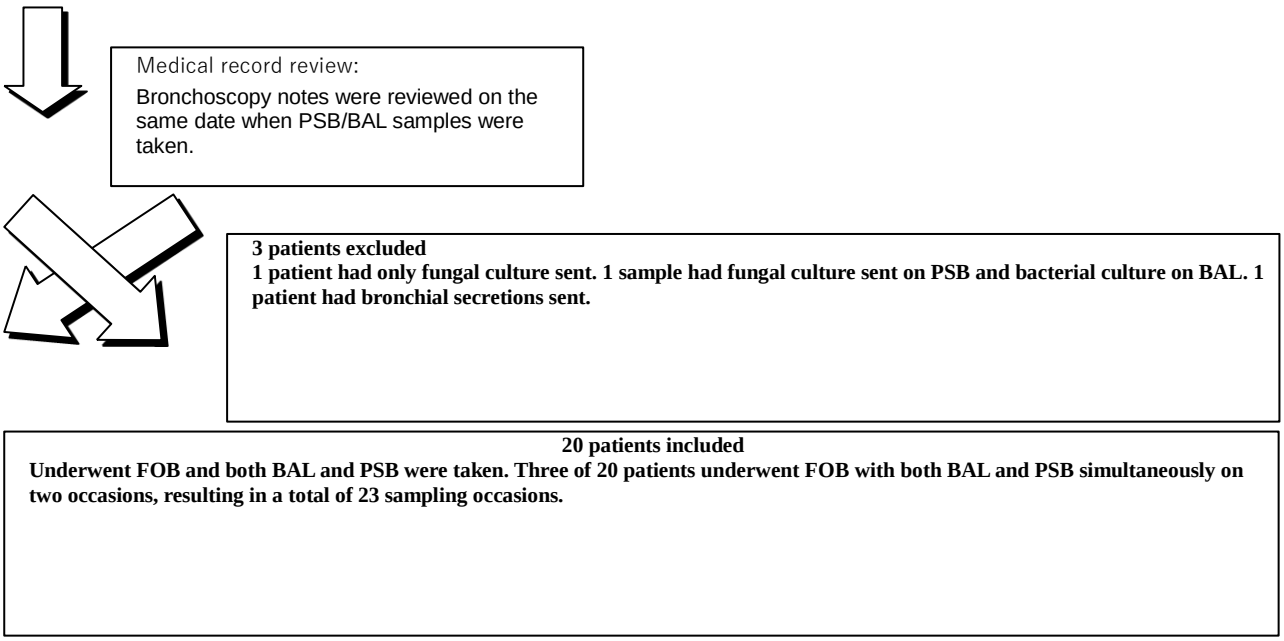


Figure (1): Flow chart of inclusion and exclusion

The mean age of the study participants was 64 years, with a range of 32-84 years. The study included 16 male and 4 female with a mean ventilator time of 10 days before the sampling occasion (see Table 1 for demographic data). During each FOB, the operator took both PSB and BAL. The samples were taken under either both muscle relaxants and sedation or only sedation. All BAL and PSB samples were sent for bacterial culture; some samples were also sent for fungal culture. In this study, only bacterial culture results were examined. In 17 sampling occasions, the patient had already been on antibiotics for more than three days before conducting FOB. On four occasions, the patient had not been on antibiotics, and on two occasions, the patient had started antibiotics within 72 hours before conducting FOB.

Table (I): Demographic Data

	Male	Female	Total
Included Patients	**16**	**4**	**20**
Age Range	**63 Year**	**69 Year**	**64 Year**
ICU Indications (Patients No.)			
Pancreatitis	**5**	**1**	**6**
Laparotomy For Colectomy	**3**	**1**	**4**
Abdominal Aorta Operation	**3**	**1**	**4**
Trauma	**3**	**0**	**3**
Decreased Level Of Consciousness	**2**	**0**	**2**
Thrombectomy	**1**	**0**	**1**

4.2. Sampling Description: Quantitative cultures were performed on all samples. The culture results were reported as identified agent and bacterial concentration in colony-forming units per milliliter (cfu/ml).

The medical record review revealed that often there was a lack of information on how the sampling was conducted, such as ventilator settings. Information was also missing on whether PSB or BAL was taken first, the amount of BAL fluid, the area where PSB/BAL was taken, and whether the operator directed PSB or BAL to the affected area.

4.3. Sampling Results: In 23 paired sampling occasions on 20 intubated or tracheostomized patients, a total of 46 samples (23 BAL and 23 PSB) were taken. Bacteria were detected in 11 of 23 BAL samples (48%) and 10 of 23 PSB samples (43%). In 22 of 23 sampling occasions (96%), the same agent was detected. The statistical analysis showed a significant correlation between BAL and PSB (correlation coefficient 0.846, $p < 0.01$), **see Figure 2.**

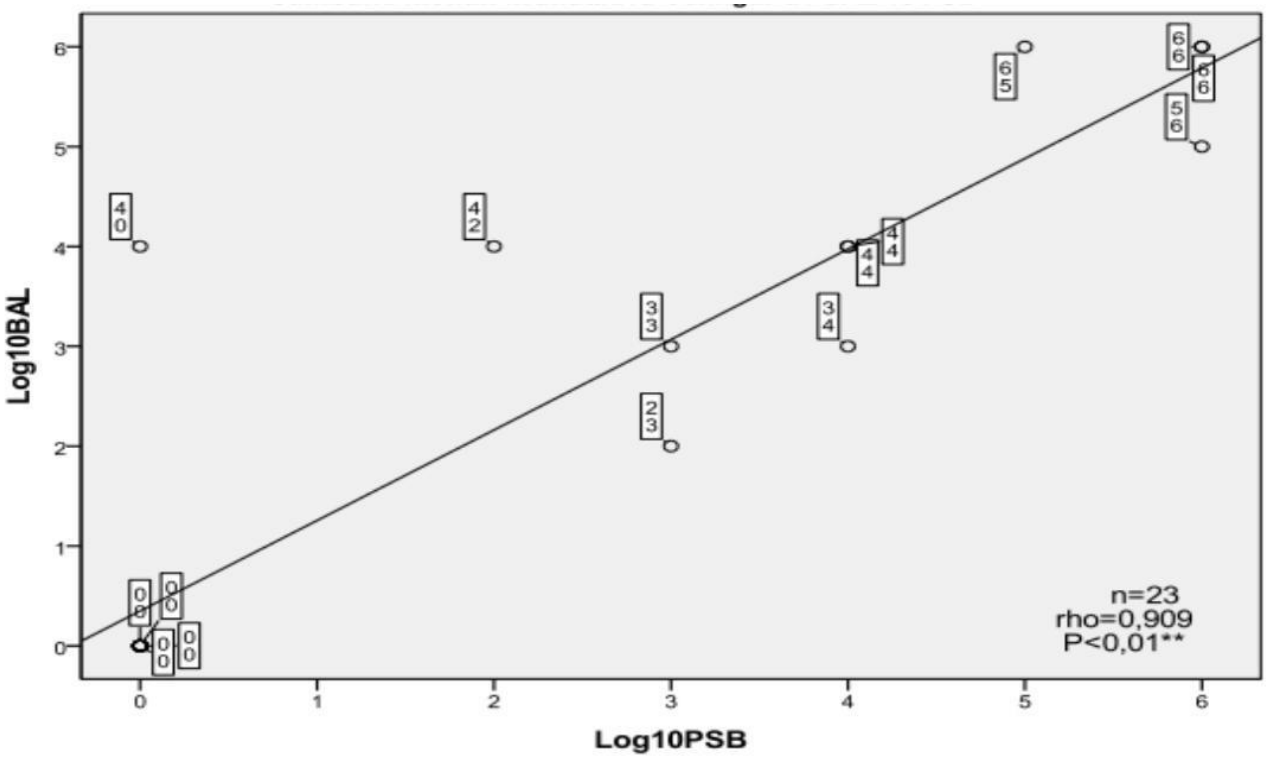


Figure (2): The relationship between quantitative cultures of BAL vs. PSB. The correlation between the variables is high (rho = 0.91) and positive, meaning that if one value increases, the other also increases. The relationship is also significant, showing that the same result can be demonstrated with 99% certainty.

In eight BAL samples (33%) and in nine PSB samples (39%), bacterial concentrations met the SIRS definition of VAP. In six of the 23 sampling occasions, both BAL and PSB were positive for VAP, but in five sampling occasions, either only BAL or only PSB was positive for VAP. See Table II for a description of the culture results.

Thi-Qar Medical Journal (TQMJ): Vol. (28), No. (2), 2024
Web Site: https://jmed.utq.edu Email: utjmed@utq.edu.iq
ISSN (Print):1992-9218 ISSN (Online): 3006-4791

Table(2) culture results

N	Ag	G	Ve	BAL	B	B	PSB	P	P	New	Ong	Indication Of ICU
1	46	M	5	S. Aureus	10^{6}	+	S. Aureus	10^{6}	+	No	No	Pacreatitis
2	73	M	10	0		-	0		-	No	Yes	Trauma
3	58	M	28	0		-	0		-	No	Yes	Pancreatitis
4	83	M	7	0		-	0		-	Yes	No	Abdominal Aorta
5	78	M	6	K.	10^{4}	+	K.	10^{3}	-	No	Yes	Pancreatitis
6	68	F	4	0		-	0		-	No	Yes	Abdominal Aorta
7	67	M	15	S. Aureus	10^{4}	+	S. Aureus	10^{4}	+	No	Yes	Decreased Level Of Consciousness
8	84	F	3	E. Coli	10^{2}	-	E. Coli	10^{3}	+	No	No	Aortic Thrombectomy
9	65	M	5	S. Aureus	10^{4}	+	S. Aureus	10^{4}	+	No	No	Pancreatitis
10	43	M	6	0		-	0		-	No	Yes	Pancreatitis
11	64	M	5	0		-	0		-	No	Yes	Trauma
12			27	E. Coli	10^{3}	-	E. Coli	10^{4}	+	No	No	Trauma
13	71	M	6	0		-	0		-	No	Yes	Op Ileus
14			13	0		-	0		-	No	Yes	Op Ileus
15	67	M	5	S.	10^{6}	+	S.	10^{5}	+	No	Yes	Abdominal Aortic
16	57	F	3	E. Coli	10^{6}	+	E. Coli	10^{6}	+	No	Yes	Op Ileus
17			6	0		-	0		-	No	Yes	Op Ileus
18	64	M	36	K.Pneumoniae Acinetob	10^{4} $10^{}$	+	0		-	No	No	Trauma
19	68	F	8	0		-	0		-	No	Yes	Pancreatitis
20	32	M	3	0		-	0		-	No	Yes	Colectomy
21	84	M	15	E. Coli	10^{5}	+	E. Coli	10^{6}	+	Yes	Yes	Op Ileus
22	63	M	5	E. Coli	10^{3}	-	E. Coli	10^{3}	+	No	Yes	Abdominal Aorta
23	43	M	4	0		-	0		-	No	Yes	Epilepsi

5. Discussion

The results showed a high level of qualitative agreement between PSB and BAL. A total of 96% of the organisms isolated from PSB samples were also found in BAL cultures. The correlation between quantitative cultures in BAL (10^4 cfu/ml) and PSB (10^3 cfu/ml) was also significant with a p-value < 0.01. Even in 2 cases where the patient had received antibiotics within 72 hours before undergoing FOB, BAL and PSB yielded identical culture results.

Among the invasive techniques proposed for evaluating mechanically ventilated patients suspected of having VAP, BAL collects secretions from the bronchial tree via the bronchoscope's aspiration channel, unlike other methods. Sampling bacteria from the distal airways with this method is influenced not only by the concentration of microorganisms in the lung parenchyma but also by their dilution in BAL fluid. Furthermore, contamination from the upper airway flora is likely. PSB allows sampling from peripheral bronchi while minimizing the risk of contamination from more proximal parts of the airways. The sample is collected using a millimeter-sized brush protected by double plastic catheters sealed with a plug [10].

The standardized method for BAL involves positioning the bronchoscope so that it isolates the airways distal to the bronchoscope tip. Approximately 100–150 ml of body-temperature saline is flushed in fractions. Subsequently, as much fluid as possible is aspirated, typically around 100 ml [7, 9]. The yield from such lavage is estimated to correspond to approximately 1 ml of fluid from peripheral airways, resulting in a dilution factor of 10–100 [8, 9, 10]. A culture result of 10^4 cfu/ml corresponds to 10^5–10^6 cfu/ml in the sampled bronchus [9]. PSB sampling with a millimeter-sized brush is estimated to yield 0.001–0.01 ml of secretion. The brush is sent to the laboratory in 1 ml of broth, resulting in a dilution of the sample material by a factor of 100–1000, and a finding of 10^3 cfu/ml corresponds to a bacterial concentration of 10^5–10^6 cfu/ml in the sampled bronchus [8, 10]. Due to these differences in sampling technique, it is crucial to compare results obtained by PSB and BAL.

During the review of medical records, it was noted that there was insufficient documentation regarding the BAL technique used and the volume of BAL fluid used during FOB. However, according to verbal information from most ICU physicians who performed the FOB, they often took samples in the bronchial tree below the trachea without wedging the bronchoscope tip into a bronchus, usually using 5–10 ml of saline for flushing and taking PSB after BAL. According to standardized methods, PSB should be taken before BAL to avoid the risk of contamination [9]. The BAL procedure was not performed correctly but rather as a bronchial lavage fluid sample or bronchial secretion sampling, where the bronchoscope was not advanced until resistance was felt and only 5–10 ml of saline was flushed.

The bronchial Aspiration technique via a suctioning tube reflects bacterial presence in the proximal airways and does not yield from lung tissue as in BAL. These cultures are more correspond to tracheal secretion cultures than to properly performed BAL, and it is unclear which threshold value should be applied to these cultures. Thus, the quantitative assessment of these cultures essentially lacks a basis[10].

It is important to note that the above mentioned bronchial lavage technique is not a mini-BAL. Mini-BAL is a non-bronchoscopic technique used in intubated patients. During this procedure, a catheter with a protected tip is advanced via the endotracheal tube until resistance is felt, after which 10–20 ml of body-temperature saline is flushed and then aspirated [11]. In a study including 64 samples from 32 ventilated patients with compromised immune function and clinical diagnosis of VAP, a comparison was made between BAL and Mini-BAL. A strong positive correlation was found between the results of BAL and Mini-BAL samples in diagnosing VAP ($r = 0.850$ and $r = 0.821$, respectively). However, a threshold of 10^5 cfu/ml was applied for Mini-BAL and 10^4 for BAL [15].

Despite BAL not being performed correctly in the present study, rather as a bronchial lavage fluid sampling, the study still demonstrated a strong positive correlation between this and PSB. PSB has been evaluated in numerous studies, with findings of $\geq 10^3$ cfu/ml considered significant [8, 10]. A meta-analysis of 18 studies involving intensive care patients demonstrated a sensitivity and specificity for bacterial pneumonia of 85% and 94%, respectively [16].

For verifying the diagnosis of VAP according to CDC guidelines, either BAL, PSB, or tracheal secretions are applicable, but not bronchial lavage fluid. Regardless of the sampling procedure, the technique is suitable for diagnostics other than quantitative culture, such as detecting mycobacteria, atypical pneumonia agents, P. jiroveci, etc. [12]. Invasive methods like bronchoscopic BAL and PSB can help avoid unnecessary use of antibiotics for clinically non-significant organisms, but there is no direct consensus or data suggesting that one method is superior to the other [13]. BAL has higher sensitivity, while PSB has higher specificity [14]. PSB is also a suitable method in cases of respiratory failure in ventilated patients where the responsible physician does not want to perform BAL correctly due to the large volume of fluid potentially increasing the risk of hypoxia [10].

6. Conclusion

In conclusion, the study shows similar results for both BAL and PSB, but the technique used for BAL was more akin to bronchial aspiration technique, which lacks a basis for clinical evaluation. In clinical practice, it may therefore be appropriate to primarily take only PSB. However, in cases where no agent is detected in PSB and there is still suspicion of VAP, a new FOB should be performed and samples taken with BAL. In such cases, flushing should be done with at least 100 ml according to international standards to include the presence of bacteria in the peripheral airways and not just in the proximal ones.

7. References

1. Ruffell A, Adamcova L. Ventilator-associated pneumonia: prevention is better than cure. Nursing in critical care. 2008 Jan;13(1):44-53.
2. Wolfensberger A, Scherrer AU, Sax H. Automated surveillance of non-ventilator-associated hospital-acquired pneumonia (nvHAP): a systematic literature review. Antimicrobial Resistance & Infection Control. 2024 Mar 6;13(1):30.
3. Shan J, Chen HL, Zhu JH. Diagnostic accuracy of clinical pulmonary infection score for ventilator-associated pneumonia: a meta-analysis. Respiratory care. 2011 Aug 1;56(8):1087-94.
4. American Thoracic S, Infectious Diseases Society of A. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. American journal of respiratory and critical care medicine. 2005 Feb 15: 171:388-416

5. Meyer, K.C., Raghu, G., Baughman, R.P., Brown, K.K., Costabel, U., Du Bois, R.M., Drent, M., Haslam, P.L., Kim, D.S., Nagai, S. and Rottoli, P., 2012. An official American Thoracic Society clinical practice guideline: the clinical utility of bronchoalveolar lavage cellular analysis in interstitial lung disease. American journal of respiratory and critical care medicine, 185(9), pp.1004-1014.
6. Fagon JY, Chastre J. Diagnosis and treatment of nosocomial pneumonia in ALI/ARDS patients. European Respiratory Journal. 2003 Aug 1;22(42 suppl):77s-83s.
7. Chastre J, Fagon JY. Ventilator-associated pneumonia. American journal of respiratory and critical care medicine. 2002 Apr 1;165(7):867-903.
8. Baselski VS, Wunderink RG. Bronchoscopic diagnosis of pneumonia. Clinical microbiology reviews. 1994 Oct;7(4):533-58.
9. Meduri GU, Chastre J. The standardization of bronchoscopic techniques for ventilator-associated pneumonia. Infection Control & Hospital Epidemiology. 1992 Nov;13(11):640-9.
10. Claesson B, Hallander H, Nyberg A, Thore M, Wollin R, Åkerlind B, editors. Referensmetodik för laboratoriediagnostik vid kliniskt mikrobiologiska aboratorier. Stockholm: Smittskyddsinstitutet; 2005.
11. M. Sezai Tasbakan a Alev Gurgun a Ozen K. Basoglu a Pervin K. Ekren a Husnu Pullukcu b Feza Bacakoglu a. Comparison of Bronchoalveolar Lavage and Mini-Bronchoalveolar Lavage in the Diagnosis of Pneumonia in Immunocompromised Patients. Departments of a Chest Diseases and Infectious Diseases and Clinical Microbiology, Ege University School of Medicine, Izmir, Turkey.
12. JOHAN PETERSSON, MATS KALIN, CHRISTIAN G GISKE Kvantitativa odlingar från nedre luftvägarna och hur de ska tolkas Infektion måste skiljas från kolonisation. LÄKARTIDNINGEN 2009-08-18 nummer 34.
13. Grossman RF, Fein A. Evidence-based assessment of diagnostic tests for ventilator-associated pneumonia: executive summary. Chest. 2000 Apr 1;117(4):177S-81S.
14. Chastre J, Combes A, Luyt CE. The invasive (quantitative) diagnosis of ventilator-associated pneumonia. Respiratory care. 2005 Jun 1;50(6):797-812.
15. Tasbakan MS, Gurgun A, Basoglu OK, Ekren PK, Pullukcu H, Bacakoglu F. Comparison of bronchoalveolar lavage and mini-bronchoalveolar lavage in the diagnosis of pneumonia in immunocompromised patients. Respiration. 2011 Feb 28;81(3):229-35.
16. Baughman RP. Protected-specimen brush technique in the diagnosis of ventilator-associated pneumonia. Chest. 2000 Apr 1;117(4):203S-6S.