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A case series of bronchoscopy and bronchoalveolar lavage in critically ill patients with pneumonia and respiratory failure

Edi Darmawan [1*], Rizki Taufiqurrahman [2], Sutan Syarif Muda Dalimunthe [3], Septian Adi Permana [4], Arie Zainul Fatoni [5], Teuku Yasir [1], Andriamuri Primaputra Lubis [6], Rommy Fransiscus Nadeak [6], Bastian Lubis [6]

[1] *Department of Anesthesiology and Intensive Care, Faculty of Medicine, Universitas Syiah Kuala / RSUD dr. Zainoel Abidin Banda Aceh*
[2] *Department of Anesthesiology and Intensive Care, RSUD dr. H. Yuliddin Away Aceh Selatan, Aceh, Indonesia*
[3] *Department of Anesthesiology and Intensive Care, RSUD H. OK Arya Zulkarnaen Batubara, Indonesia*
[4] *Department of Anesthesiology and Intensive Therapy, RSUD dr. Moewardi, Surakarta, Central Java, Indonesia*
[5] *Department of Anesthesiology and Intensive Therapy, Faculty of Medicine, Universitas Brawijaya / RSUD dr. Saiful Anwar*
[6] *Department of Anesthesiology and Intensive Therapy, Faculty of Medicine, Universitas Sumatera Utara / RSUP H. Adam Malik Medan*

***Corresponding Author**: Edi Darmawan, E-mail: edidarmawan.lkmi@gmail.com

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ABSTRACT

Introduction: Flexible bronchoscopy with bronchoalveolar lavage (BAL) is used in the ICU for sampling the lower respiratory tract and clearing secretions. We describe our experience with bronchoscopy for diagnosis and treatment in critically ill patients with pneumonia and respiratory failure.

Methods: This retrospective case series involved 18 critically ill adults with pneumonia and respiratory failure undergoing bronchoscopy with BAL in the ICU. BAL culture results, blood inflammatory markers (total leukocyte count, neutrophil and lymphocyte percentages, and neutrophil-to-lymphocyte ratio [NLR]), arterial blood gas values, and radiographic changes were recorded before and after the procedure. No hypothesis testing was conducted.

Results: BALF culture was positive in all patients, yielding 22 isolates. Gram-negative bacilli predominated (19/22 isolates; 86.4%), with Acinetobacter baumannii most frequent (9 patients; 50%), followed by Klebsiella pneumoniae and Pseudomonas aeruginosa; four patients (22.2%) had polymicrobial growth. Postoperatively, median leukocyte count was lower than baseline (21.69 vs 13.24 $\times 10^3/\mu L$; lower in 15 patients), and median NLR decreased (10.97 vs 5.85; lower in 14 patients), with increased lymphocyte percentage. Radiographic infiltrates regressed in 13 patients (72.2%); pH, $PaCO_2$, and arterial oxygen saturation were stable.

Conclusion: This case series shows bedside bronchoscopy with BAL provided high microbiological yield of multidrug-resistant Gram-negative organisms, with improvement in inflammatory markers and radiographic infiltrates. As all patients received antimicrobial therapy and supportive care, changes cannot be solely attributed to bronchoscopy; nonetheless, it illustrates bronchoscopy's diagnostic and therapeutic role in the ICU.

Keywords

Bronchoscopy, Bronchoalveolar Lavage, Ventilator-Associated Pneumonia, Acinetobacter Baumannii, Neutrophil-To-Lymphocyte Ratio, Intensive Care Unit

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INTRODUCTION

Hospital-acquired pneumonia (HAP) and ventilator-associated pneumonia (VAP) are among the most common and serious nosocomial infections in the intensive care unit (ICU) and are leading contributors to antimicrobial use, prolonged mechanical ventilation, and attributable mortality. Timely identification of the causative

pathogen and prompt, adequate pathogen-directed therapy are central to management; however, the clinical and radiographic features of pneumonia are nonspecific in critically ill patients, and empirical regimens are increasingly challenged by multidrug-resistant (MDR) gram-negative organisms [1-4]. Flexible bronchoscopy plays a dual role in this setting. As a diagnostic tool, bronchoalveolar lavage (BAL) samples the lower respiratory tract under direct vision from the radiographically involved segment, providing material for culture that is generally regarded as more representative of distal airway flora than endotracheal aspiration [5-7]. As a therapeutic tool, bronchoscopy permits the aspiration of retained secretions and mucus plugs and the re-expansion of atelectatic lungs. Because it can be performed at the bedside, the procedure avoids the hazards of transporting an unstable patient out of the ICU [9,10].

We present a single-center case series of critically ill patients with pneumonia and respiratory failure who underwent bronchoscopy with bronchoalveolar lavage (BAL), reporting the microbiological yield along with the observed pre- and post-procedure course of peripheral inflammatory markers, arterial blood gases, and chest radiographs. The study was descriptive in nature, aiming to illustrate the practical diagnostic and therapeutic use of bronchoscopy in this population rather than testing its efficacy.

METHOD

We conducted a retrospective, descriptive case series of consecutive critically ill adults admitted to the ICU of RSUP H. Adam Malik Medan, a tertiary referral hospital in Medan, Indonesia during December 2025 who were diagnosed with pneumonia complicated by respiratory failure and underwent flexible bronchoscopy with BAL as part of clinical care. Eligible patients were adults (≥18 years) with a clinical and radiographic diagnosis of pneumonia and concomitant respiratory failure in whom bronchoscopy was clinically indicated for lower respiratory tract sampling and/or secretion clearance.

Flexible bronchoscopy was performed at the bedside by trained operators. After inspection of the tracheobronchial tree, BAL was obtained from the segment corresponding to the radiographic abnormality, and retained secretions were aspirated as a therapeutic maneuver. The lavage fluid was subjected to microbiological culture and identification. For each patient, we recorded the chest radiograph appearance and BAL culture results, together with the following parameters at two time points—before the procedure ("pre") and after the procedure ("post"): total peripheral leukocyte count ($\times 10^3/\mu L$), neutrophil and lymphocyte percentages, and arterial blood gas values (pH, PaO_2, $PaCO_2$, and arterial oxygen saturation). The neutrophil-to-lymphocyte ratio (NLR) was calculated as the neutrophil percentage divided by the lymphocyte percentage. The radiographic course was classified as regression or increase of the infiltrate on the post-procedure film relative to the pre-procedure film. Consistent with a descriptive case-series design, no formal hypothesis testing was performed. Continuous variables are summarized as medians and interquartile ranges (IQR), and categorical variables as counts and percentages; for the laboratory parameters, the number of patients in whom the value was lower or higher at the post-procedure assessment than at baseline is also reported, and individual trajectories are tabulated (Table 1). One post-procedure leukocyte value was not analyzable owing to a data-entry artifact and was excluded (n=17 for the leukocyte count; n=18 for all other variables). Data were tabulated using SPSS 23.0.

RESULTS

Eighteen critically ill patients with pneumonia and respiratory failure who underwent bronchoscopy with BAL were included in this study. On the pre-procedure chest radiography, the infiltrate was bilateral in the majority of patients, predominantly right-sided in several, and reported as normal in one; the per-patient findings are listed in Table 1. BAL culture was positive in all 18 patients (diagnostic yield: 100%), yielding 22 isolates. Gram-negative bacilli accounted for 19 of the 22 isolates (86.4%). Acinetobacter baumannii was the most common organism, recovered in nine patients (50% of the cohort; 40.9% of all isolates), followed by Klebsiella pneumoniae subsp. pneumoniae (four patients) and Pseudomonas aeruginosa (three patients). Gram-positive cocci (Streptococcus pneumoniae and Staphylococcus aureus, one each) and a single fungal isolate (Candida

tropicalis) were uncommon. Four patients (22.2%) had polymicrobial growth, in each instance involving at least one gram-negative organism. The full distribution is shown.

Table 1. Per-patient clinical, microbiological, and laboratory summary (n=18).

Pt	CXR infiltrate	Radiograph	WBC pre	WBC post	NLR pre	NLR post	BAL isolate(s)
1	Right lower	Regressed	23.78	17.08	21.19	6.44	A. baumannii
2	Bilateral	Regressed	25.48	15.47	9.90	6.75	A. baumannii
3	Left mid/lower	Regressed	12.40	11.50	3.82	3.67	K. pneumoniae + A. baumannii
4	Bilateral mid/lower	Regressed	22.34	26.42	27.55	59.19	P. aeruginosa
5	Right (fibrosis)	Regressed	11.42	9.78	6.26	4.27	K. pneumoniae
6	Bilateral	Regressed	17.58	12.30	40.61	8.55	A. baumannii + E. coli
7	Bilateral	Increased	21.69	11.05	22.43	11.47	S. pneumoniae
8	Bilateral	Increased	8.05	7.80	7.65	4.96	S. aureus + A. baumannii
9	Bilateral	Increased	24.27	15.86	36.80	5.26	A. baumannii
10	Bilateral	Regressed	24.42	25.76	11.90	14.20	P. aeruginosa
11	Bilateral	Regressed	20.34	13.46	2.26	3.44	K. pneumoniae + A. baumannii
12	Bilateral	Regressed	17.37	—*	5.38	20.64	Aeromonas caviae
13	Normal	Regressed	23.17	18.63	21.19	12.81	A. baumannii
14	Bilateral	Increased	21.96	14.78	8.29	3.23	K. pneumoniae
15	Right lower	Increased	19.76	13.24	12.74	2.98	Candida tropicalis
16	Right	Regressed	18.60	11.40	10.05	4.98	P. aeruginosa
17	Right	Regressed	17.82	12.60	6.96	4.47	Pseudomonas putida group
18	Bilateral	Regressed	23.40	13.24	20.07	6.68	A. baumannii

Note: WBC, total leukocyte count (×10³/μL); NLR, neutrophil-to-lymphocyte ratio; CXR, chest radiograph. *Post-procedure leukocyte value for patient 12 not analyzable owing to a data-entry artifact. Species abbreviations: *A. baumannii*, *Acinetobacter baumannii*; *K. pneumoniae*, *Klebsiella pneumoniae*; *P. aeruginosa*, *Pseudomonas aeruginosa*; *E. coli*, *Escherichia coli*; *S. pneumoniae*, *Streptococcus pneumoniae*; *S. aureus*, *Staphylococcus aureus*.

BAL culture was positive in all 18 patients (diagnostic yield: 100%), yielding 22 isolates. Gram-negative bacilli accounted for 19 of the 22 isolates (86.4%). Acinetobacter baumannii was the most common organism, recovered in nine patients (50% of the cohort; 40.9% of all isolates), followed by Klebsiella pneumoniae subsp. pneumoniae (four patients) and Pseudomonas aeruginosa (three patients). Gram-positive cocci (Streptococcus pneumoniae and Staphylococcus aureus, one each) and a single fungal isolate (Candida tropicalis) were uncommon. Four patients (22.2%) had polymicrobial growth, in each instance involving at least one gram-negative organism. The full distribution is shown in Table 2.

Table 2. Microbiological isolates recovered from bronchoalveolar lavage

Organism	Isolates (n)	% of isolates	Patients (n)
Acinetobacter baumannii	9	40.9	9
Klebsiella pneumoniae subsp. pneumoniae	4	18.2	4
Pseudomonas aeruginosa	3	13.6	3
Escherichia coli	1	4.5	1
Streptococcus pneumoniae	1	4.5	1
Staphylococcus aureus	1	4.5	1
Aeromonas caviae	1	4.5	1
Pseudomonas putida group	1	4.5	1
Candida tropicalis	1	4.5	1
Total	22	100	18

The course of peripheral inflammatory markers is summarized in Table 3. The median total leukocyte count was lower at the post-procedure assessment than at baseline (21.69 vs 13.24 ×10³/μL), being lower in 15 of 17 patients, and the median neutrophil percentage was likewise lower (87.5% vs. 81.8%, lower in 15 of 18). The median lymphocyte percentage was higher (8.05% vs. 14.10%, higher in 14 of 18), and the median NLR was lower (10.97 vs. 5.85, lower in 14 of 18). The direction of change was therefore consistent across most patients, with individual exceptions (for example, patients 4 and 10, in whom the leukocyte count and

NLR increased. Acid–base status and oxygenation were broadly stable after the procedure: the median pH was 7.37 before and 7.38 after, the median $PaCO_2$ was 44.5 and 44.0 mmHg, respectively, and arterial oxygen saturation remained at 98–99% in all patients. The median PaO_2 was lower after the procedure (136 vs. 116 mmHg); however, the fraction of inspired oxygen was not recorded; therefore, this difference cannot be interpreted as a change in oxygenation and most plausibly reflects the de-escalation of supplemental oxygen as patients stabilized. The post-procedure chest radiography showed regression of the infiltrate in 13 of 18 patients (72.2%) and an increase in five (27.8%). Percentages were calculated from the total of 22 isolates. The total number of patients was more than 18 because four patients had polymicrobial growth.

Table 3. Peripheral inflammatory markers before and after bronchoscopy (descriptive)

Parameter	Pre, median [IQR]	Post, median [IQR]	Lower / higher (n)
Total leukocyte count ($\times 10^3/\mu L$)†	21.69 [17.82–23.40]	13.24 [11.50–15.86]	15 / 2
Neutrophils (%)	87.5 [84.9–91.1]	81.8 [80.0–86.6]	15 / 3
Lymphocytes (%)	8.05 [4.30–12.05]	14.10 [8.25–18.00]	4 / 14
Neutrophil-to-lymphocyte ratio	10.97 [7.13–21.19]	5.85 [4.32–10.74]	14 / 4

Note: IQR, interquartile range. "Lower / higher (n)" = number of patients in whom the parameter was lower/higher at the post-procedure assessment than at baseline. †n=17 (one non-analysable post-procedure value excluded); all other rows, n=18. Consistent with the descriptive case-series design, no hypothesis testing was performed. Arterial blood gas values are described in the text.

DISCUSSION

In this descriptive case series of critically ill patients with pneumonia and respiratory failure, bronchoscopy with BAL served a dual practical purpose. Diagnostically, it produced a positive culture in every patient and identified a microbiological profile dominated by gram-negative bacilli, with Acinetobacter baumannii present in half of the cohort. Therapeutically, the procedure included aspiration of retained secretions, and the subsequent course was characterized by lower systemic inflammatory markers and radiographic regression of infiltrates in most patients. A high diagnostic yield is consistent with prior ICU experience, in which BAL obtained under direct vision samples the affected segment and frequently provides organism identification that can refine empirical therapy and support antimicrobial stewardship. The predominance of Acinetobacter baumannii, Klebsiella pneumoniae, and Pseudomonas aeruginosa mirrors the pathogen distribution reported in ICU bronchoscopy series and in contemporary HAP/VAP guidelines, in which these MDR-prone gram-negative organisms are leading causes of nosocomial pneumonia [11-16]. The recovery of such organisms has direct management implications because adequate empirical coverage and timely de-escalation depend on local microbiology and susceptibility data, which BAL is well-placed to provide [5-7].

The therapeutic contribution of bronchoscopy in the ICU for the clearance of secretions and re-expansion of atelectatic lungs has been well described, and radiographic improvement after the procedure has been reported when lobar or segmental collapse is present [8,10]. In our series, the leukocyte count, neutrophil percentage, and NLR were lower, and the lymphocyte percentage was higher in most patients at the post-procedural assessment. The NLR is an inexpensive, widely available marker that integrates neutrophilic stress response and infection-related lymphopenia, and higher values have been associated with worse outcomes in sepsis and pneumonia [15-17]; Therefore, the direction of change observed here is clinically favorable. Importantly, all patients concurrently received antimicrobial therapy and supportive critical care over the same interval; therefore, these changes cannot be attributed to bronchoscopy and are best regarded as descriptive of the overall clinical course rather than as evidence of a procedural effect. Two further observations warrant caution. Although the median PaO_2 was lower after the procedure, arterial oxygen saturation was maintained and the pH and $PaCO_2$ remained unchanged; in the absence of the inspired oxygen fraction, the PaO_2 difference is uninterpretable and may simply reflect weaning of supplemental oxygen. The finding that the radiographic infiltrate increased in five patients underscores the heterogeneous course of severe pneumonia and the fact that a single procedure does not reverse established consolidation in every case.

This report describes a small, retrospective, single-center case series without a comparator group; it is descriptive in design, no hypothesis testing was performed, and no causal inference can be drawn. Demographic data (age, sex), comorbidities, the primary admitting diagnosis, ventilation status, illness-

severity scores, and the explicit indication for each procedure were not available in the analyzed dataset and must be added before submission. Antimicrobial susceptibility results were not captured, which limits the interpretation of the gram-negative isolates; procalcitonin was available in only two patients. Patient-centered outcomes—ICU and hospital length of stay, duration of mechanical ventilation, and mortality—whether BAL results changed antimicrobial management, and any peri-procedural complications were not recorded, and the inspired oxygen fraction was unavailable, precluding the calculation of the PaO_2/FiO_2 ratio. The timing of the postoperative assessment was not standardized. These elements should be incorporated, and a prospective controlled study should be conducted before the independent diagnostic and therapeutic impact of bronchoscopy can be established.

CONCLUSION

In critically ill patients with pneumonia and respiratory failure, bedside bronchoscopy with BAL provided a high microbiological yield, dominated by MDR-prone Gram-negative pathogens, most often Acinetobacter baumannii, and the subsequent course was characterized by improvement in systemic inflammatory markers and radiographic infiltrates. As an uncontrolled descriptive series, it cannot establish a procedural effect; however, it illustrates the practical diagnostic and therapeutic role of bronchoscopy in the ICU and supports its further evaluation in controlled studies that report patient-centered outcomes.

DECLARATIONS

Ethics approval and consent to participate. Not applicable. Owing to the retrospective and descriptive nature of this case series, formal ethics committee approval was not required. Informed consent was obtained from all patients for the use of their de-identified clinical data.

CONSENT FOR PUBLICATION

The authors agree to the publication of this article in the Journal of Society Medicine.

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AUTHORS' CONTRIBUTIONS

All authors have reviewed and approved the final version of the manuscript, and are accountable for all aspects of the work.

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