Severe Pneumonia Management and Bronchoalveolar Lavage Efficacy in Yunnan's Ethnic Minorities

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Abstract: This investigation evaluates the therapeutic effectiveness of bronchoalveolar lavage (BAL) for severe pneumonia in ethnic minority groups within the Pu'er district. We conducted a prospective, randomized controlled trial involving 68 patients diagnosed with severe pneumonia, assigning 37 to the treatment cohort and 31 to the control cohort. Patients in the treatment cohort underwent BAL, whereas their counterparts received standard care. Outcomes measured were the persistence of clinical symptoms, hospital stay duration, healthcare costs, and hematological markers including leukocyte count, procalcitonin (PCT), and arterial blood gases. Results indicated that the treatment cohort benefitted from a notable reduction in fever, cough, pulmonary rales, and antibiotic administration durations compared to the control (p<0.05). Furthermore, they experienced expedited symptom resolution and incurred lower hospitalization expenses (p<0.05). Arterial blood gas analyses revealed that the treated cohort's post-therapeutic oxygen partial pressures and oxygenation indices were substantially elevated (p<0.05). Although transient supraventricular tachycardia and dips in oxygen saturation were observed, these were not statistically significant (p=0.497). The application of BAL demonstrated pronounced clinical improvements, notably in pulmonary function and in diminishing the duration and cost of hospital care, underscoring its viability and safety with adequate monitoring. The findings offer valuable clinical insights and substantiate BAL's role in managing severe pneumonia in Pu'er and comparable regions.

1. Introduction

Situated along the Sino-Myanmar border, Pu'er is a prefecture-level city in Yunnan known for its rich tapestry of cultures. The city's remote setting and modest economic progression, paired with the constraints in healthcare infrastructure, pose considerable obstacles in managing acute medical conditions[1]. In particular, severe pneumonia, a critical phase of pulmonary disease with potential to precipitate respiratory failure and compromise other organ systems, presents heightened challenges for treatment in the ethnically diverse border regions of Pu'er[2].

The region's pathogen variety and the age-specific responses to conventional treatments underscore the limitations of existing therapeutic approaches[3]. Hence, the exploration of innovative

treatment modalities, such as bronchoalveolar lavage (BAL), becomes crucial in enhancing the management of severe pneumonia within these communities. Presently, BAL is a sophisticated therapeutic technique conducted with the aid of an electronic bronchoscope[4]. This procedure entails the introduction of saline into the bronchoalveolar space and subsequent retrieval of the fluid for analysis of alveolar lining fluid, allowing for the examination of cellular elements and soluble materials. While BAL has demonstrated promise in the treatment of severe pneumonia[5], its practical application and clinical benefits for the distinctive demographic of ethnic minorities in Pu'er remain under-investigated. This study seeks to evaluate the clinical efficacy of BAL in addressing severe pneumonia among the minority populations in the Pu'er locale. By conducting a thorough assessment of inflammatory markers and blood gas parameters, the research will probe the potential utility and therapeutic impact of BAL in severe pneumonia cases. Given the distinctive geographical and socio-cultural context of Pu'er, this research holds considerable importance for augmenting the standard of local healthcare services and may offer valuable therapeutic insights applicable to other areas with analogous features.

2. Research Subjects and Methods

2.1 Methodology

We conducted a forward-looking, randomized controlled trial. Selection criteria targeted individuals hospitalized with a diagnosis of severe pneumonia at the Respiratory and Critical Care Medicine unit of Pu'er City People's Hospital from February 2022 to December 2023, culminating in a cohort of 68 patients.

2.2 Participants

Our participants were those diagnosed with severe pneumonia within the specified department at the Pu'er City People's Hospital during the study timeline.

Inclusion criteria incorporated: (1) individuals aged 16 and above; (2) patients meeting the clinical and diagnostic benchmarks for severe pneumonia; (3) documented informed consent from patients or their legal guardians; (4) no previous interventions with electronic bronchoscopy or bronchoalveolar lavage (BAL).

Exclusion criteria encompassed: (1) documented allergies to any study medications or methodologies; (2) significant organ dysfunction including cardiac, hepatic, or renal impairment; (3) current pregnancy or lactation; (4) communicative impairments due to cognitive disorders; (5) any psychiatric conditions or emotional instability affecting consent or compliance.

2.3 Allocation and Blinding

Subjects were randomized into either the study or control group, with 37 in the former and 31 in the latter, employing a single-blind design where participants remained unaware of their groupings, unlike the research team.

2.4 Intervention Protocols

Upon admission, all patients received a comprehensive treatment regimen that included antimicrobial therapy, antispasmodics, expectorants, electrolyte stabilization, and nutritional support. For cases where respiratory failure persisted, adjunctive ventilation was provided. Specifically, the study group underwent BAL during their hospital stay.

2.4.1 BAL Technique

Electronic bronchoscopes used were the Japanese Olympus BF-1T150 and BF-1T290 electronic bronchoscopy systems. Patients in the study group underwent BAL within 3 days after completing the relevant examinations upon admission.

Before BAL treatment, patients were routinely fasted for 4 to 6 hours. The patient was placed in a supine position, and local anesthesia with 2% lidocaine was applied to the nasopharyngeal area. An appropriate electronic bronchoscope was selected based on the patient's specific condition and physical status, and it was slowly inserted through the nasal cavity into the bronchus. Throughout the intubation process, the patient's trachea and various levels of bronchi, including the main bronchus, lobar bronchus, and smaller bronchi, were carefully observed for any congestion, edema, accumulation of secretions, or abnormal lesions.

Upon reaching the infected lesion with the bronchoscope, secretions were first collected with a brush for bacterial culture. Then, 37℃ saline was slowly instilled for lavage, 10 to 20 ml per instillation. A negative pressure of 100 to 150 mmHg was used to aspirate and recover the lavage fluid, repeating the operation 5 to 6 times until the aspirated fluid was clear. After each lavage, the collected lavage fluid was used for etiological culture and drug sensitivity testing. For lung segments with a lot of secretions and severe inflammation, lavage fluid (sterile saline 50mL + Gentamicin 80,000U or sensitive antibiotics + Dexamethasone 5mg, warmed to about 37℃) was used for repeated pressure lavage, performing bronchoalveolar lavage about 3 times.

2.4.2 Control Group Care

The control group received conventional treatments, including systemic anti-infection treatments with antibiotics, postural drainage, and symptomatic supportive therapy, etc.

2.4.3 Monitoring

Continuous monitoring of pulse oximetry saturation (SpO2) was essential. Any drop below 80% necessitated an immediate cessation of lavage and administration of supplemental oxygen until parameters normalized and the procedure could resume.

2.5 Research Indicators

These indicators are critical for evaluating the effectiveness of the treatment and understanding its implications on patient health outcomes. These indicators are critical for evaluating the effectiveness of the treatment and understanding its implications on patient health outcomes.

2.5.1 Clinical Symptoms and Costs

Duration of fever, cough, pulmonary rales, recovery time of symptoms, hospital stay, hospitalization costs.

2.5.2 Hematological Biochemical Indicators

Fasting venous blood samples (3mL) were collected before and after treatment (at admission and on the 3rd day after treatment) for analysis. Within 30 minutes after blood collection, the samples were centrifuged at 4℃ at 3,000 rpm for 10 minutes for further use, and blood leukocyte count and PCT (procalcitonin) levels were measured.

2.5.3 Pulmonary Ventilation Function Indicators

Arterial blood samples (3-5mL) were collected for analysis within the first week before and after treatment. A blood gas analyzer (Danish Radiometer ABL90 FLEX model, Bayer fully automatic blood gas analyzer) was used to measure blood oxygen partial pressure (PaO2) and the concentration of inhaled oxygen (FiO2) to calculate the oxygenation index (OI).

The oxygenation index (OI) calculation formula: OI = (PaO2 $\times$ mPaw)/FiO2.

2.6 Ethical

Endorsed by the Ethics Committee of Pu'er City People's Hospital, the study guaranteed informed consent with participants retaining withdrawal rights, ensuring ethical adherence.

2.7 Statistical Methods

R software (version 4.3) facilitated our statistical evaluation. Continuous variables were tested for normal distribution with the Kolmogorov-Smirnov test. Non-normal distributions, such as pre- and post-treatment PCT levels, were described using median and interquartile ranges, while normally distributed variables were articulated as means $\pm$ standard deviations. Non-parametric methods were applied as necessary, with all testing being bidirectional and set at an alpha level of 0.05.

3. Research Results

3.1 Demographic Profile of Participants

Our study encompassed a total of 68 individuals, divided into 37 participants in the experimental cohort and 31 in the control cohort. Gender distribution across both cohorts revealed no significant statistical variance: 56.8% male and 43.2% female in the experimental cohort versus 51.6% male and 48.4% female in the control (x^2=0.18, p=0.808). Age distribution spanned from 16 to 84 years across participants, with an average age of(56.57$\pm$11.87) years in the experimental cohort and (55.06$\pm$16.96)years in the control, yielding no significant discrepancy (t=0.43, p=0.67). Regarding ethnic composition, the Lahu and Yi minorities were the most represented in the experimental and control cohorts, constituting 24.3% and 16.4%, respectively. Minority ethnicities comprised 91.9% of the experimental cohort and 93.5% of the control, with no statistically notable differences (p=0.8678). These demographic similarities between cohorts suggest a high level of comparability. (Table 1).

Table 1: General Demographic Characteristics of the Study Subjects (n=68)

Variable	Study Group (n=37)	Control Group (n=31)	x^2/t	df	p
Gender (n, %)					
Male	21 (56.80)	16 (51.60)	0.18	1.oo	0.808
Female	16 (43.20)	15 (48.40)			
Age (years; $\overline{x} \pm s$)	56.57$\pm$11.87	55.06$\pm$16.96	0.43	66.00	0.67
Ethnicity (n, %)					
Lahu	9 (24.32)	10 (32.26)			
Yi	9 (24.32)	6 (19.35)		0.8678*	
Dai	5 (13.51)	6 (19.35)			

Wa	6 (16.22)	3 (9.68)	
Hani	2 (5.41)	2 (6.45)	
Miao	1 (2.70)	2 (6.45)	
Blang	2 (5.41)	0 (0.00)	
Han	3 (8.11)	2 (6.45)	

Note: *Fisher's exact test was used.

3.2 Inflammatory Biomarker Level Comparison Pre and Post-Intervention

Initial WBC counts presented no notable difference (t=0.21, p=0.649). Post-treatment day three, the experimental cohort's WBC count reduced to $(7.73 \pm 2.27) \times 10^9$/L, while the control's stood at $(9.67 \pm 2.81) \times 10^9$/L, marking a statistically significant post-treatment variance (t=-3.06, p=0.003).

Pre-treatment median PCT levels stood at 2.48ng/L for the experimental cohort and 2.33 ng/L for the control, with the Mann-Whitney U test revealing no significant difference (U=532.5, z=-0.51, p=0.614). However, post-treatment day three saw the experimental cohort's median PCT level drop to 0.33ng/L, contrasting with the control's 0.82ng/L, a difference of statistical significance (U=123.000, z=-5.549, p<0.0001) (Table 2).

Table 2: Comparison of Inflammatory Marker Levels Before and After Treatment between the Two Groups (n=68)

Group	WBC(10^9/L)		PCT(ng/L)	
	Before Treatment ($\bar{x} \pm$s)	After 3 Days ($\bar{x} \pm$s)	Before Treatment (M;P25,P75)	After 3 Days (M;P25,P75)
Study Group	20.28±5.65	7.73±2.27	2.48(1.18,9.39)	0.82(0.64,1.01)
control group	16.72±5.65	9.67±2.81	2.33(1.02,11.40)	0.33(0.17,0.57)
t/u	0.21	-3.06	532.5	123
df	66.00	66.00	-*	-#
p	0.649	0.003	0.614	1e-04&

Note: The z-values for PCT by Mann-Whitney U test before and after treatment were: *z=-0.51and #z=-5.54; &: p<0.0001

3.3 Blood Gas Parameter Comparative Analysis Pre and Post-Intervention

Blood gas analysis revealed no significant pre-treatment differences in PaO2 (t=0.67, p=0.505). However, post-treatment week one, the experimental cohort's PaO2 significantly rose from (71.45±13.20) mmHg to (97.05±9.87) mmHg, compared to the control's (84.68±12.08) mmHg, signifying a statistically substantial difference (t=4.65, p<0.0001). The OI also demonstrated no pre-treatment significant difference but post-treatment week one, the experimental cohort's OI significantly escalated to (331.92±63.54)mmHg versus the control's (303.55±44.85)mmHg, a statistically significant distinction (t=2.09, p=0.041).(Table 3).

Table 3: Comparative Analysis of Blood Gas Parameters before and after Treatment between the Two Groups (n=68)

Group	PaO2 (mmHg)			OI(mmHg)	
	Before Treatment ($\bar{x} \pm$s)	After 1 Week ($\bar{x} \pm$s)		Before Treatment ($\bar{x} \pm$s)	After 1 Week ($\bar{x} \pm$s)
Study Group (n=37)	71.45±13.20	97.05±9.87		222.51±46.71	331.92±63.54

Control Group (n=31)	69.37±12.24	84.68±12.08		238.09±47.09	303.55±44.85
t	0.67	4.65		-1.37	2.087
df	66.00	66.00		66.00	66.00
p	0.505	0.0001		0.177	0.041

3.4 Post-Treatment Clinical Symptom and Hospitalization Indicator Comparison

The experimental cohort exhibited a significant reduction in fever duration, cough, pulmonary rales, and antibiotic use compared to the control, with all variances proving statistically significant ($p<0.05$). The experimental cohort also displayed a significantly shorter clinical symptom recovery time ($t=-2.63$, $p=0.011$). Moreover, the experimental cohort incurred significantly lower hospitalization costs (¥9424.41±3932.86) than the control (¥13620.97±1150.75), signifying a substantial economic burden reduction ($t=-2.08$, $p=0.041$). (Table 4)

Table 4: Comparison of Clinical Symptoms, Hospitalization Time, and Hospitalization Costs after Treatment ($\bar{x}\pm s$)

Variable	Study Group (n=37)	Control Group (n=31)	t	df	p
Duration of Fever (d)	2.89±1.43	4.03±1.79	-2.92	66.00	0.049
Duration of Cough (d)	5.14±1.32	7.52±2.47	-5.17	66.00	1^{e-04}
Duration of Pulmonary Rales (d)	7.16±1.39	8.90±3.03	-3.133	66.00	0.003
Duration of Antibiotic Use (d)	7.19±2.62	9.00±3.45	-2.455	66.00	0.017
Time to Recovery of Clinical Symptoms (d)	9.62±2.51	11.23±2.50	-2.63	66.00	0.011
Hospitalization Costs (CNY)	9424.41±3932.86	13620.97±1150.75	-2.08	66.00	0.041

3.5 Complications

The control cohort experienced no serious complications during the treatment period. Conversely, the experimental cohort recorded one instance of transient supraventricular tachycardia and one of diminished oxygen saturation, both ameliorated by suspending the intervention and administering concentrated oxygen therapy. The complication occurrence rate was 5.41% in the experimental cohort against 0.00% in the control, a difference not statistically significant by Fisher's exact test ($p=0.497$).

4. Discussion

Our findings reveal that bronchoalveolar lavage (BAL), performed via electronic bronchoscopy, markedly ameliorates clinical symptoms and improves pulmonary function parameters in severe pneumonia patients among ethnic minorities in border areas. The treatment cohort saw considerable decreases in the persistence of fever, cough, pulmonary rales, antibiotic duration, and overall recovery time when juxtaposed with the control group ($p<0.05$), alongside a notable reduction in hospitalization expenses ($p=0.041$). These results align with existing research affirming BAL's role in severe pneumonia management[6,7], highlighting its utility as a valuable supplementary therapy in acute pneumonia care [8].

In remote borderlands, especially within ethnic minority populations, disseminating and implementing BAL encounters distinct hurdles. Cultural and linguistic barriers often leave many, particularly the elderly, with a limited grasp of contemporary medical practices [9]. Initial interventions frequently resort to traditional remedies or occur in non-formal medical settings,

contributing to treatment delays and potential aggravation of the illness. Hence, elevating the profile and acceptance of BAL and similar contemporary interventions is critical for enhancing healthcare in these communities.

Moreover, the invasive nature of BAL necessitates judicious application among minority groups in frontier regions. Apprehensions about the procedure and its perceived risks may incline patients towards conventional therapies [10]. Healthcare providers must acknowledge these reservations, ensuring thorough communication to elucidate BAL's benefits and risks, and its advantages over traditional approaches. Personalized treatment strategies, tailored monitoring, and support are also imperative for these patient groups [11].

Clinically, despite instances of decreased oxygen saturation and tachycardia during BAL, prompt resolution through intervention underscores BAL's safe, effective application with proper monitoring. Mastery of indications, contraindications, procedural guidelines, and risk management is essential for patient safety [11].

In essence, while BAL exhibits therapeutic promise, frontier regions necessitate enhanced medical dialogue, procedural refinement, and alleviation of patient trepidation regarding invasive treatments. Future directives should focus on educational outreach concerning BAL, cultural sensitivity in medical service provision, and broader acceptance of this efficacious therapy.

To encapsulate, BAL presents significant therapeutic merit for severe pneumonia, particularly in underserved minority locales. To optimize safety and effectiveness, a patient care management approach that is culturally and socially attuned is required.

Acknowledgement

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