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Comparative Evaluation of the Role of Non-bronchoscopic vs Bronchoscopic Techniques for the Diagnosis of Ventilator-Associated Pneumonia

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Abstract

Background and objectives: Ventilator-associated pneumonia is a common form of hospital-acquired pneumonia that develops after 48 hours from intubation and mechanical ventilation. This study aims to compare the results of distal airway sampling for the diagnosis of Ventilator-Associated Pneumonia between Non-bronchoscopy and bronchoscopy Techniques.

Methods: This was a prospective case-control diagnostic study. The study was conducted over five months among patients with clinical suspicion of Ventilator Associated Pneumonia, who were admitted to the intensive care unit at Emergency Teaching Hospital and Azadi Teaching Hospital in Duhok City, from 1st May 2023 to 30th September 2023. We compared two methods of distal airway secretion to diagnose the infection: Non-Bronchoscopic protected Bronchoalveolar lavage and Bronchoscopic Broncho alveolar lavage.

Results: Acinetobacter baumanii (27.5%) was the most prevalent organism detected on Bronchoscopic Broncho alveolar lavage, followed by Klebsiella pneumonia 22.5% while on non-Bronchoscopic protected Bronchoalveolar lavage the most common organism detected was Klebsiella pneumonia (22.5%) followed by Acinetobacter baumanii (20%). Bronchoscopic Broncho alveolar lavage was more sensitive at 100% compared to 92.3% than non-Bronchoscopic protected Bronchoalveolar lavage, but the latter was more specific at 28.6% compared to 21.4%. additionally, the earlier was significantly associated with Clinical Pulmonary Infection Score, p-value 0.037, while the later was 0.129

Conclusion: ventilator associated pneumonia is a challenging diagnosis that requires clinical signs with suspicion followed by the appropriate laboratory diagnostic techniques. Both techniques were sensitive to Ventilator Associated Pneumonia detection, with Broncho alveolar lavage receiving a higher privilege.

Keywords: Bronchoscopic Broncho alveolar lavage, non-Bronchoscopic protected Bronchoalveolar lavage, Ventilator-Associated Pneumonia

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Introduction

Ventilator-associated pneumonia (VAP) is a form of hospital-acquired pneumonia that develops 48 hours after intubation and mechanical ventilation.[1] The disease is usually seen among intubated patients on ventilators who are bedridden in the intensive care unit (ICU) for over 48 hours and who develop one or more of the following features: new infiltration on chest radiograph or progressive infiltration, leukocytosis, and secretions from the tracheobronchial tree.[1] It is a common problem among ICU-admitted cases that require special attention due to an increased risk of death.[2] The disease is typically caused by a single bacterium; nonetheless, polymicrobial infections can be encountered. The most common microorganisms are Staphylococcus aureus among the gram-positive and Pseudomonas aeruginosa among the gram-negative; the latter is regarded as the most common pathogen.[3] Risk factors include male in gender, advanced age, prolonged length on ventilation and use of mechanical ventilation, lower Glasco Coma Score and disorders of consciousness such as severe brain injury, patients with burn, comorbidities such as hypertension, coronary artery disease, and diabetes, chronic renal failure, prior use of antibiotic therapy and smoking.[4] The main risk factor and the mechanism that leads to the development of VAP is the endotracheal tube (ETT). The tube impairs the body's natural defense mechanism by impairing cuff reflex and mucociliary clearance such as a decrease in their velocity Additionally, the presence of the cuff creates a mechanical obstacle for mucus clearance, and finally, it allows for direct communication between oral-supraglottic space and the lower respiratory tract. The other mechanism includes bacterial colonization of the ETT with subsequent biofilm formation and proliferation.[5] Diagnosis requires a high index of suspicion combined with patients' clinical setting and microbiological analysis of respiratory secretions.[1] The diagnosis requires a set combination of the clinical conditions of the patients combined with radiographic and Microbiological findings. The microbiologic diagnostic techniques include two methods of sampling: invasive and non-invasive techniques for sampling in the distal airways.[6] This study was aimed at assessing Ventilator-Associated Pneumonia by comparing samples from distal airway sampling between non-bronchoscopy and bronchoscopy Techniques.

Patients and methods

This study was conducted as a case-control study. The study took a total of 5 months, from 1st May 2023 to 30th September 2023, to be completed. A total of 100 cases were collected during this period. All cases with clinical suspicion of VAP who were admitted to the intensive care unit (ICU) at Azadi Teaching Hospital and Emergency Teaching Hospital in Duhok City were initially included. Two procedures were performed among patients, NP-BAL and B-BAL, and both were compared to diagnose VAP. The inclusion criteria were clinical suspicion of VAP[3], age ≥18 years (pediatric age group was excluded), and patients on mechanical ventilators. After identifying the included cases, each patient underwent both procedures; first non-bronchoscopic protected Bronchoalveolar lavage (NPBAL) and then bronchoscopic BAL (B-BAL) were performed, followed by comparing the results of both samples. For each case with clinical suspicion, the Clinical Pulmonary Infection Score (CPIS) was calculated; a score of ≥ 6 is highly suggestive of pneumonia, fever, leukocytosis, tracheal aspirates, oxygenation, radiographic infiltrates, and semi-quantitative cultures of tracheal aspirates. Subsequently, each sample was evaluated via microbiological culture. The first procedure, NP-BAL, was performed through a double catheter technique with a

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sterile suction tube sized 16 Fr, which was inserted through the endotracheal tube and blindly advanced into the distal airway until resistance was felt. Before the insertion of the suction catheter, an 8-fr in size and 50cm-long catheter was wedged in place. A sterile container was prepared, and through the inner tube, 20 milliliters of normal saline were instilled into the distal airway, followed by placing the aspirated sample into the sterile container. The quantity of the aspirate was recorded at the time of the procedure; if the fluid aspirate was less than 5 ml, the procedure was repeated. The samples were then sent for bacteriological examination and quantitative culture. Bronchoscopic Broncho alveolar lavage B-BAL was performed later, starting with the insertion of an oropharyngeal airway to prevent biting and damage to the scope. Before starting the procedure, the ventilator setting was adjusted by at least 5 minutes; the adjustment included increasing tidal volume (Vt) by 100 ml and FiO2 to 100%. Throughout the procedure, the patient's vital signs were monitored continuously. Depending on the chest radiograph for the detection and sampling of the desired sample, the bronchoscope was inserted, and the tip was wedged to the distal bronchi draining the bronchopulmonary segment. In cases of diffuse-bilateral lung infiltrates, the right lower lobe was sampled. A 20 ml of sterile saline was inserted into the working lumen and aspirated through the sucker. The amount of aspiration was noted and made sure to be adequate or repeated. Following bronchoscopy and after finishing the procedure, the external surface of the fiber optic bronchoscope was cleaned through immersion in the detergent solution following each procedure. The patient was monitored for a one-hour post-procedure, and FiO2 was kept at 100 for one hour, and then the settings of the ventilators were rechecked and changed according to the patient's requirements. All data were analyzed using SPSS version 26 and a p value of < 0.05 was regarded as statistically significant. Approval was obtained from the Kurdistan Higher Council of Medical Specialization.

Results

Table (1) shows the prevalence of each organism detected by the different methods of the sample collection on BAL. The most common pathogen detected was Acinetobacter baumanii (27.5%) followed by Klebsiella pneumonia 22.5%, and no growth was seen in 3 cases (7.5%). By NP- BAL, the most common organism detected was Klebsiella pneumonia (22.5%) followed by Acinetobacter baumanii (20%), while the chance of no growth on the sample was much higher; 6 cases (15%).

Table (1): Prevalence of the organism according to the method of sample collection

Type of the organism	BAL	(%)	NP-BAL	(%)
Acinetobacter baumanii	11	27.5	8	20
candida spp.	1	2.5	2	5
Escherichia coli	3	7.5	2	5
klebsiella pneumonia	9	22.5	9	22.5
no growth	3	7.5	6	15
Pseudomonas aeruginosa	6	15	5	12.5
staph. Aureus	3	7.5	3	7.5
Staph. heamolyticus	4	10	4	10
Streptococcus spp.	0	0	1	2.5
Total	40	100	40	100

From the cases that showed no growth on NP-BAL, their results on BAL were as follows; only 16.7% of them showed no growth on the BAL method as well, while the remaining sample showed growth of Klebsiella pneumonia 33.3%, Staph. Aureus 33.3%, and Escherichia coli 16.7% as shown in Table (2).

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Table (2): BAL culture reports of the cases that showed no growth on NP-BAL

Bacteria	No (%).
Escherichia coli	1 (16.7)
Klebsiella pneumonia	2 (33.3)
No growth	1 (16.7)
Staph. Aureus	2 (33.3)
Total	6 (100)

Table (3) demonstrates the values of various sampling techniques. BAL was more sensitive at 100% compared to 92.3% than NP-BAL, but the latter was more specific at 28.6% compared to 21.4%.

Table (3): Diagnostic values of the studied sample

Sampling technique	Sensitivity	Specificity	PPV*	NPV*
BAL	100	21.4	70.3	100
NP-BAL	92.3	28.6	70.6	66.7

*Positive predictive value*Negative predictive value

Table (4) Shows the correlation of and NP-BAL showed a p-value of 0.129 which was statistically non-significant.

Table (4): Correlation of CPIS and NP-BAL

Count				
		cpis		Total
		<6	>6	
NP-BLA	Acinetobacter baumanii	2	6	8
	candida spp.	2	0	2
	Escherichia coli	0	2	2
	klebsiella pneumonia	3	6	9
	no growth	4	2	6
	Pseudomonas aeruginosa	0	5	5
	staph. aureus	2	1	3
	staph.heamolyticus	1	3	4
	streptococcus spp.	0	1	1
Total		14	26	40

Table (5) shows the correlation of CPIS to BAL which showed a p-value of 0.037 which was statistically significant.

Table (5): Correlation of CPIS and BAL

Count				
		CPIS		Total
		<6	>6	
BAL	Acinetobacter baumanii	5	6	11
	candida spp.	1	0	1
	Escherichia coli	1	2	3
	klebsiella pneumonia	1	8	9
	no growth	3	0	3
	Pseudomonas aeruginosa	0	6	6
	staph. aureus	2	1	3
	staph.heamolyticus	1	3	4
Total		14	26	40

Discussion

Invasive diagnostic sampling using bronchoscopy has been proven to provide good results; however, the procedure itself requires an experienced operator and carries a significant risk, especially among patients with pneumonia presenting with thrombocytopenia and hypoxemia.[6-8] For this reason, a newer sampling method was created to overcome these limitations, which is known as mini BAL or NP-protected BAL (NP-BAL); a non-invasive procedure done blindly using an endobronchial catheter that is wedged in the tracheobronchial tree.[9] Ventilator Associated Pneumonia is the most common cause of nosocomial infections and has been shown to complicate 8-28% of the cases of mechanical ventilation and increase mortality, especially among patients with high-risk pathogens.[9] This study assesses and compares the role of two methods of distal airway sampling, NP-BAL and B-BAL, for sampling pathogens from patients who are admitted to the ICU. Ventilator Associated Pneumonia can cause difficulty weaning off the ventilator and increase the duration of hospital stay.[10] The most common

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mechanism thought to be responsible for the development of VAP is through the progressive colonization of the upper airway, progressing to the lower airway, and ending in pneumonia.[11] Patients who are intubated have altered ciliary motion and mucus secretions; inhibition of gag reflex; and providing a substrate for the growth of biofilms for the pathogen all act in favor of developing VAP.[11] The most common pathogen identified is Staphylococcus aureus, followed by Pseudomonas aeruginosa and Acinetobacter baumanii.[11-12] However, in this study, using the BAL method, the most prevalent microorganism to be detected was Acinetobacter baumanii (27.5%) followed by Klebsiella pneumonia (22.5%), and vice versa for the NP-BAL method: 22.5% for Klebsiella and 20% for Baumanii. However, Agarwal et al., in their article, identified P. aeruginosa as the most common organism isolated in both methods.[6] This discrepancy in the type of microorganism could be based on the population of the patients in the ICU, duration of hospitalization, and prior use of antimicrobial agents.[9] Several risk factors have been identified to increase the risk of VAP, such as; increased duration of mechanical ventilation, prolonged hospitalization, comorbidities, and invasive operations. These factors act independently to place patients at risk of VAP.[10] We found that the sensitivity of BAL (100%) was higher compared to NP-BAL (92.3%), similarly, a higher sensitivity was found in the B-BAL method compared to NP-BAL by Agarwal et al.[6] Thus, NP-BAL has a high sensitivity of 92.3% and a specificity of 70.6% for the detection of the pathogen in our samples. Similar results were seen in other articles.[13-14] In this study, the correlation of CPIS was statistically significant in correlation to BAL, however, this was not-significant in correlation to NP-BAL indicating that BAL is much more significant in detection of bacteria.

Limitations of the Study

In this study we had a small number of cases due to the minimum number of cases available in our ICUs. We recommend a longer period of follow-up for which to collect a much larger amount of data for more accurate results.

Conclusion

Mechanical ventilators, despite being an effective tool for saving the lives of critical patients during ICU stays, can negatively impact their lives through VAP. Identifying the infectious agents responsible for VAP among ICU patients is crucial because appropriate antibiotic therapy will be initiated to improve the outcomes.NP-BAL is an effective method for VAP detection. According to our study, BAL had a greater sensitivity compared to NP-BAL and is more significant in the process of detection of bacterial pathogens. Further studies are needed to identify the cause behind.

Conflict of Interest

None.

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