Original Article

Access this article online

Quick Response Code:

Website: www.eurasianjpulmonol.com

DOI: 10.4103/ejop.ejop_16_18

Effect of sputum bacteriology on the prognosis of patients with acute exacerbations of bronchiectasis in the Intensive Care Unit

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Abstract:

OBJECTIVE: In bronchiectasis cases, isolation of the bacterial infection agent is related with disease severity. The purpose of the study was to find the impact of bacterial infections on the prognosis of bronchiectasis exacerbations in patients hospitalized in the Intensive Care Unit (ICU).

MATERIALS AND METHODS: A retrospective, single-center, clinical study was performed on 48 patients who were diagnosed as having bronchiectasis exacerbation in the ICU. Sputum cultures of the patients were collected at the time of ICU admission. Clinical characteristics, treatment with noninvasive ventilation, IV requirement, and mortality were recorded.

RESULTS: The bacteriologic sputum examination was positive in 24 patients. The bacteriologic analysis of sputum cultures revealed *Pseudomonas aeruginosa* in 12 patients, *Streptococcus pneumoniae* in 4, *Haemophilus influenzae* in 3, *Acinetobacter baumannii* in 3, and *Escherichia coli* in 2 patients. Seventeen patients needed IV during ICU follow-up, 7 of whom died. Bacterial proliferation in sputum culture was correlated to IV treatment need ($P = 0.005$). The radiologic disease extent was greater in patients with culture proliferation ($P = 0.028$). The patients who needed IV treatment had a greater radiologic disease extent ($P = 0.007$), pulmonary artery systolic pressure pulmonary arterial pressure (PAP) ($P = 0.004$), C-reactive protein ($P = 0.014$), and number of hospital admissions ($P = 0.017$). A multiple regression analysis for treatment success involving the variables of PAP, culture results, and radiologic disease extent revealed that bacterial proliferation was the most important factor for treatment success (odds ratio: 2.05; confidential interval: [0.87–3.23]; $P = 0.04$).

CONCLUSION: Positive bacterial examination of sputum is the most important prognostic factor for patients with bronchiectasis exacerbation admitted to the ICU.

Keywords:

Acute respiratory failure, bronchiectasis exacerbation, bronchiectasis, sputum culture

Introduction

Bronchiectasis is described as indelibly dilated airways due to chronic or recurrent infection and chronic bronchial inflammation caused by improper clearance of several microorganisms.[1] With the exception of cystic fibrosis (CF), there are inadequate data regarding bronchiectasis. Despite previously being thought of as an orphan illness,[2] it is nowadays obvious that the prevalence of non-CF bronchiectasis (NCFB) remains high.[3] Recurrent attacks are a fundamental cause of morbidity and mortality and may promote significant economic and social costs, as observed through escalated hospitalizations and medical service use.[4]

Admission to the Intensive Care Unit (ICU) of patients with NCFB is unusual but has built up over time and correlates with the

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How to cite this article: Çiftci F, Mülazimoglu DD, Erol S, Çiledag A, Kaya A. Effect of sputum bacteriology on the prognosis of patients with acute exacerbations of bronchiectasis in the Intensive Care Unit. Eurasian J Pulmonol 2018;20:85-92.

high mortality rate. This needs to be considered with regard to the designation of medical care resources and designing respiratory units.[5] Our knowledge is limited about the prognosis of patients with NCFB who have acute hypercapnic respiratory failure (AHRF) in the ICU.[6] AHRF maintains a primary reason for mechanical ventilation (MV) in patients with chronic respiratory disease in the ICU. Noninvasive ventilation (NIV) as a first-line supportive therapy may be used. The use of NIV to treat exacerbations of chronic obstructive pulmonary disease (COPD) is promoted by findings of randomized research and therefore advised.[7] As well as in clinical practice, NIV is used beyond guidepost suggestions,[8] and in spite of concern about the efficaciousness of NIV in sustaining treatment of acute renal failure (ARF) in patients with preexisting diseases other than COPD, NIV is generally regarded as a first-option respiratory therapy in patients with NCFB.[6,9] There is a demand to evaluate NIV use in patients with NCFB over a period of several years, like that carried out in patients with COPD.

Pseudomonas aeruginosa persistence has been shown to be connected with worse pulmonary function, more widespread disease, and low-grade quality of life.[10,11] It has characteristically been supported that patients with bronchiectasis with seriously afflicted lung function are believed at high risk of *P. aeruginosa* infections.[12]

The primary outcome of the study was to determine sputum bacteriologic microorganisms, IV requirement, and death during follow-up in the ICU, which were collectively considered as therapy failure. The secondary outcome was to ascertain the correlation between sputum culture results and therapy failure.

Materials and Methods

Patients

We enrolled all consecutive patients with bronchiectasis exacerbation who were on treatment in the ICU for ARF between January 2011 and December 2016. Etiologic assignment was established the standards recommended by Pasteur *et al*.[13] NCFB was diagnosed based on high-resolution computed tomography (HRCT) imaging of the thorax.[2] Patients with a definitive diagnosis of CF and COPD were excluded from the study. COPD and COPD exacerbation were described consistent with the Global Initiative for Chronic Obstructive Lung Disease criteria.[14] ARF was diagnosed as either[1] hypoxemic which means partial pressure of arterial oxygen (PaO_2) <60 mmHg in room air or[2] hypercapnic, which means partial pressure of arterial carbon dioxide ($PaCO_2$) >45 mmHg, respiratory failure with or without academia.[15]

Data collection

The authors FC and DDM registered the following through medical record database on to standardized datum collection forms: age, sex, body mass index, smoking habit, previous therapies, comorbid disorders, history of tuberculosis, previous thoracic surgery or resection history, bronchiectasis-related complications (respiratory failure, cor pulmonale, empyema, metastatic abscess, amyloidosis, and hemoptysis), types, dosages, and durations of medications (inhaled corticosteroids, inhaled anticholinergics, inhaled long-acting beta-2 agonists, oral acetyl cysteine, and antibiotics), long-term oxygen therapy (LTOT) history, the number of hospitalizations within the last year, arterial blood gas analysis, the type and radiologic extent of bronchiectasis, pulmonary artery pressure, results of sputum cultures, IV requirement, mortality, and length of stay in the ICU. Spontaneous sputum samples were collected at admission before antibiotic administration. Arterial blood gas (ABG) measurements and ventilator settings were recorded. ABG analyses were performed immediately before and at 1, 2, 12, and 24 h after the initiation of NIV treatment, and daily thereafter if needed. Health status was determined using the acute physiology and chronic health evaluation (APACHE) II score and level of consciousness with the Glasgow Coma Score (GCS).

Type (cystic, cylindrical, or varicose) and location of bronchiectasis were determined according to thoracic HRCT. The radiologic disease extent was determined on the basis of the number of the affected bronchopulmonary segments in HRCT.[16] Patients were grouped by bronchiectasis in 1–5 bronchopulmonary segments, bronchiectasis in 6–9 bronchopulmonary segments, and bronchiectasis >9 bronchopulmonary segments.

Empiric broad-spectrum antibiotic therapy, nebulized short-acting bronchodilators, and systemic steroids were administered to all patients.

Mechanical ventilation

NIV was managed by four ICU physicians who were also among the authors of this manuscript. NIV sessions were applied using Hans Rudolph 6600 V2 oronasal masks (Hans Rudolph Inc., US) with V60 (Philips Respironics Inc., US) and VENTImotion (Weinmann; Hamburg, Germany) ventilators. For treatment of AHRF, pressure support (spontaneous/timed) mode was administered as the first option. One hour after treatment, arterial blood gases were measured; the response to NIV was assessed and NIV settings were modified accordingly. ABG samples were obtained through a direct vascular puncture of the radial artery, which was performed at the bedside. The samples were instantly studied using

an ABL 90 flex/blood Gas Analyzer (Radiometer Ltd. Brønshøj, Denmark), which was available in the ICU. ABG analyses were performed immediately before and at 1, 2, 12, and 24 h after the initiation of NIV treatment, and daily thereafter if needed. ABG results and adjustments were registered on forms designed for the study.

Pressure support was initially established at 8–10 cmH_2O and raised step-by-step to a maximum of 30 cmH_2O until the exhaled tidal volume was 8–10 mL/kg of ideal body weight. Expiratory positive airway pressure (EPAP) was adjusted at 5 cmH_2O and enhanced if required to manage hypoxemia. The fraction of inspired oxygen (FiO_2) of the machine was set to preserve arterial oxygen saturation (SpO_2) at more than 90% in pulse oximetry and arterial blood gas examination. With the exception of pauses for feeding and treatment administration, NIV support was provided continuously for the first 24 h, as long as it could be tolerated by the patients.

Non-invasive MV was considered successful when pH exceeded 7.35 during spontaneous breathing without further worsening of neurologic signs; respiratory rate was reduced to <24 breaths/min; heart rate decreased to <90 beats/min; patient awareness improved; and pH exceeded 7.35 with adequate SaO2 in room air and a with low fraction of inspired O2 (FiO2 < 30%) for at least 48 h. Acute hypoxemic respiratory failure was described as recent dyspnea with a respiratory frequency >25 breaths/minute and/or sternocleidomastoid muscle contraction with pneumonic infiltrates on chest X-ray and a $PaCO_2$ less than or up to 45 mmHg.

For management of acute hypoxemic respiratory failure, first oxygen supplement with a reservoir face mask was used, followed by a high-flow oxygen system, and then NIV with continuous PAP (CPAP) was used if SpO_2 was <90%. CPAP was delivered through the same ventilators using a face mask as an interface with an initial positive end-expiratory pressure of 8 cmH_2O, with adjustable FiO_2 within the 35%–100%, and set to maintain an SpO_2 of at least 92%, as previously reported.[17] For at least the first 12 h, CPAP was given constantly and then periodically as required based on patient tolerance and whether pulse oximetry SpO_2 was >90% with oxygen supplementation alone. The pressure level could be raised to 10 cmH_2O as demanded based on the clinical response and tolerance.

The need for intubation and IV support was based on one of the following criteria: (1) pH: <7.20, (2) pH: 7.20–7.25 on two observations 1 h apart, (3) hypercapnic coma (GCS <8 and $PaCO_2$ >60 mmHg), (4) PaO_2 <45 mmHg even maximum tolerated FiO_2, and (5) cardiorespiratory arrest. Therapy failure was specified as the demand for IV with endotracheal intubation and/or ICU death.

Outcomes

These included sputum culture proliferation, NIV and IV need, ICU mortality, and ICU stay. We described treatment failure as the requirement for IV or death within the same ICU admission.

Statistical analysis

The descriptive statistics for categorical variables are expressed as frequency (percentage) and median (range) or mean ± standard deviation for continuous variables, depending on the normality of distribution. One-sided analysis of variance was used for the comparison of continuous variables when the parametric test assumptions were met, or the Kruskal–Wallis test if not. Chi-square or Fisher's exact test was used for the comparison of categorical variables across the study groups. Statistical significance was indicated at $P < 0.05$. Several candidate variables identified in a univariate Cox regression analysis were examined using the multiple Cox model with the forward listening-reading method to determine independent predictors of treatment success. SPSS version 20.0 for Windows (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses.

Results

The baseline characteristics of the 48 patients with bronchiectasis (26 females and 22 males) enrolled in the study are presented in Table 1.

The mean age of study group was 67.1 ± 15.8 years. The etiology of bronchiectasis was idiopathic in 10 (20.8%) patients, tuberculosis in 15 (31.2%), recurrent pneumonia in 12 (25%), rheumatoid arthritis in 8 (16.7%), and immune deficiency in 3 (6.3%) patients. The mean duration of ICU stay was 7.4 ± 3.1 days.

Bronchiectasis types were cystic in 24 (50%) patients, varicose in 13 (27.1%), and cylindrical in 11 (22.9%) patients. The radiologic disease extent was determined on the basis of the number of the affected bronchopulmonary segments in HRCT. Twelve (25%) patients had bronchiectasis in 1–5 bronchopulmonary segments, 13 (27.1%) had 6–9 diseased bronchopulmonary segments, and 23 (47.9%) patients had >9 diseased bronchopulmonary segments. Twenty-eight (58.3%) patients were using LTOT.

The mean number of hospital admissions for respiratory system disorders in the last year was 2.6 ± 1.3. The mean pH was 7.29 ± 0.05, the mean $PaCO_2$ was 72.1 ± 17.2 mmHg, and the mean PaO_2/FiO_2 was 184.6 ± 50.1. The mean systolic PAP was 49.5 ± 11.6

mmH_2O. GCS was found as 14.1 ± 2.2 and APACHE II was 20.3 ± 5.7.

Twenty-three (47.9%) patients were admitted directly from the emergency department, 19 (39.6%) from a general ward, and 6 (12.5%) patients were admitted from the outpatient clinic [Figure 1]. Seven (14.6%) patients had acute hypoxemic respiratory failure, 3 (6.2%) of whom were given oxygen supplement using a reservoir face mask, 1 (2.1%) was given oxygen supplement through a high-flow oxygen system, and 3 (6.2%) had NIV treatment with CPAP. One of the patients who had oxygen supplement and 2 of the patients who received NIV treatment needed IV during ICU follow-up, 2 (4.2%) of whom died. Forty-one (85.4%) patients with bronchiectasis were ventilated with NIV bilevel PAP (BPAP) for AHRF, 15 (31.2%) of which needed IV during ICU follow-up; 5 (10.4%) of whom died. Forty-four (91.6%) patients had NIV treatment with BPAP or CPAP. The overall mortality rate was 14.6%.

Table 1: The baseline characteristics of the 48 patients with bronchiectasis enrolled in the study

Baseline characteristics	n (%) or mean±SD
Age	67.1±15.8
Female, *n* (%)	26 (54.2)
BMI (kg/m^2)	23.2±2.4
Smoking history, pack years	34.3±17.1
Bronchiectasis etiology, *n* (%)	
Idiopathic	10 (20.8)
Tuberculosis	15 (31.2)
Recurrent pneumonia	12 (25)
Rheumatoid arthritis	8 (16.7)
Immune deficiency	3 (6.3)
Bronchiectasis types, *n* (%)	
Cystic	24 (50)
Varicose	13 (27.1)
Cylindrical	11 (22.9)
Radiologic extent, *n* (%) (number of affected bronchopulmonary segments)	
1-5	12 (25)
6-9	13 (27.1)
>9	23 (47.9)
LTOT, *n* (%)	28 (58.3)
Arterial blood gas measurements	
pH	7.29±0.05
PaO_2/FiO_2	184.6±50.1
$PaCO_2$	72.1±17.2
PAP	49.5±11.6
GCS	14.1±2.2
APACHE II	20.3±5.7
Sputum bacteriologic examination	
Pseudomonas aeruginosa	12 (25)
Streptococcus pneumonia	4 (8.3)
Haemophilus influenzae	3 (6.2)
Escherichia coli	2 (4.2)
Acinetobacter baumannii	3 (6.2)

LTOT: Long-term oxygen treatment, PAP: Pulmonary artery pressure, APACHE: Acute Physiology and Chronic Health, GCS: Glasgow Coma Score, PaO_2: Partial pressure of arterial oxygen, FiO_2: Fraction of inspired oxygen, $PaCO_2$: Partial pressure of arterial carbon dioxide, BMI: Body mass index

The sputum bacteriologic examination was positive in 24 (50%) patients. The bacteriologic analysis of sputum cultures revealed *P. aeruginosa* in 12 (25%) patients, *Streptococcus pneumoniae* in 4 (8.3%), *Haemophilus influenzae* in 3 (6.2%), *Acinetobacter baumannii* in 3 (6.2%), and *Escherichia coli* in 2 (4.2%). The number of hospital admissions for respiratory system disorders in the last year according to bacterial agents is presented in Table 2. *P. aeruginosa* proliferation in sputum culture was significantly correlated with the number of hospital admissions in the last year (P = 0.03). Furthermore, two patients (4.2%) whose sputum culture revealed *P. aeruginosa* were admitted to ICU in the last year. Seventeen (35.4%) patients needed IV during ICU follow-up. The sputum bacterial culture was found positive in 19 (39.6%) patients with NCFB who were treated with BPAP because of AHRF. Fifteen of these patients needed IV and 11 (22.9%) had positive sputum culture results.

The sputum bacterial culture was found positive in 3 (6.2%) patients with NCFB who were treated with CPAP because of acute hypoxemic respiratory failure. Two (4.2%) patients needed IV, and both had *P. aeruginosa* proliferation in sputum culture. There was no relation between bacterial agents which were proliferated in sputum culture and duration of ICU stay (P = 0.318).

There was no statistically significant correlation between age and NIV treatment success and mortality (P = 0.234 and P = 0.114, respectively). A comparison of the hypoxemic and hypercapnic respiratory failure groups is given in Table 3. The mortality rate was higher in patients with hypoxemic respiratory failure (P = 0.04). Positive sputum bacteriologic examination rates were not different between the hypoxemic and hypercapnic respiratory failure groups. Bacterial proliferation in sputum culture was correlated to IV treatment need (P = 0.004). The radiologic disease extent was greater in patients with culture proliferation (P = 0.03). The patients who did not need IV treatment had a

Table 2: The relation between bacterial agents and the number of hospital admissions in the last year

Sputum bacteriologic examination	Hospital admissions, *n*			
	0	1	2	>2
None	19	7	2	2
Pseudomonas aeruginosa	2	2	6	2
Streptococcus pneumonia	1	3	0	0
Haemophilus influenzae	2	1	0	0
Escherichia coli	1	0	1	0
Acinetobacter baumannii	1	2	0	0

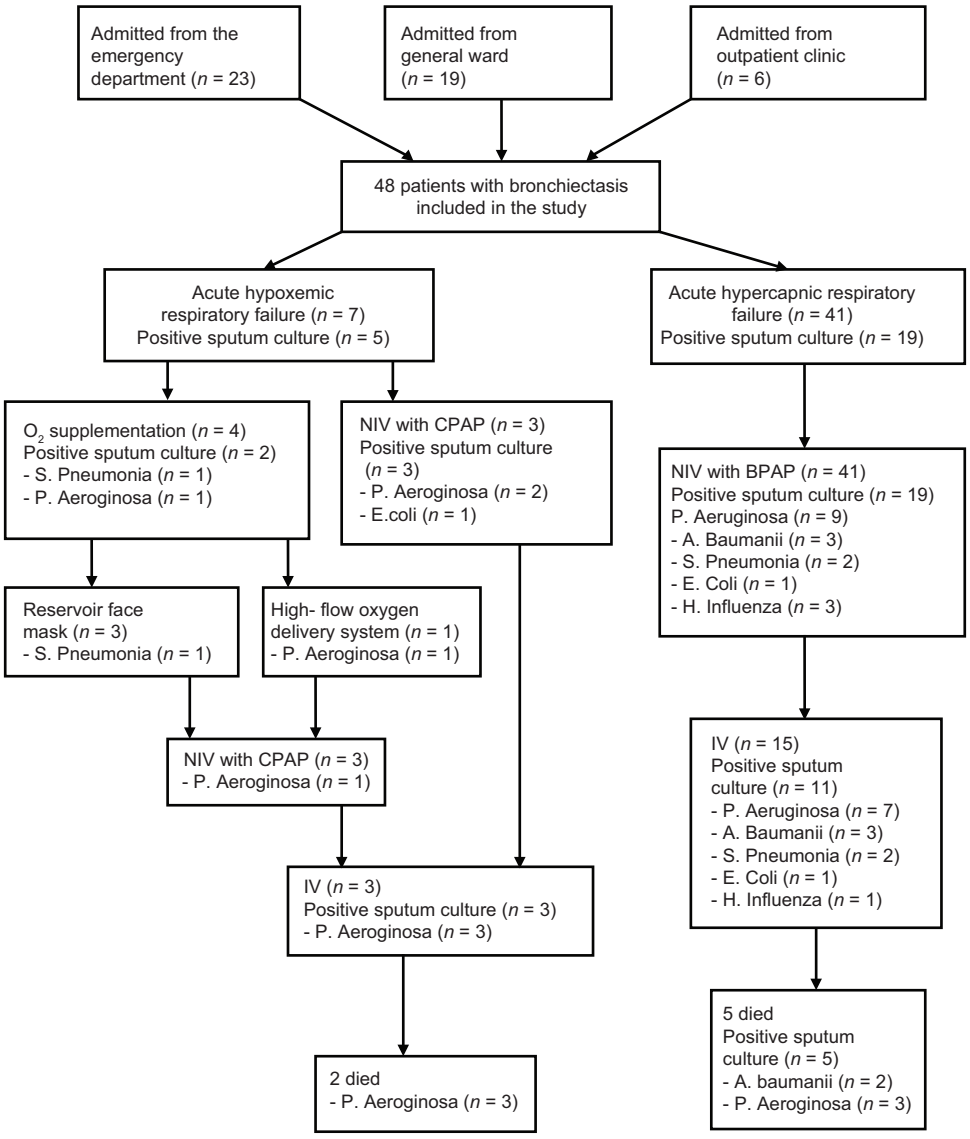

Figure 1: Inclusion, Intensive Care Unit follow-up, and outcomes of the patients

Table 3: Comparison of characteristics of acute hypoxemic and hypercapnic respiratory failure patient groups

	Hypoxemic respiratory failure (*n*=7)	Hypercapnic respiratory failure (*n*=41)	*P*
Age	65.3±12.4	70.1±19.2	NS
Positive sputum bacteriologic examination	5 (71.4)	19 (46.3)	NS
Invasive ventilation	3 (42.8)	15 (36.6)	NS
PAP	48.5±8.4	50.4±18.7	NS
GCS	13.9±2.6	14.5±1.1	NS
APACHE II	23.4±2.5	19.1±6.2	NS
ICU stay	8.2±2.5	6.5±4.3	NS
Mortality	2 (28.6)	5 (12.2)	0.04

PAP: Pulmonary artery pressure, APACHE: Acute Physiology and Chronic Health, GCS: Glasgow Coma Score, ICU: Intensive Care Unit, NS: Not significant

lower radiologic disease extent ($P = 0.007$) and number of hospital admissions ($P = 0.017$). PAP ($P = 0.005$) and C-reactive protein (CRP) ($P = 0.014$) were significantly correlated with IV treatment need. A multiple regression analysis for survival involving the variables of PAP, culture results, and radiologic disease extent revealed that bacterial proliferation was the most important factor for treatment success (odds ratio [OR]: 2.05; 95% confidential interval [CI]: [0.87–3.23]; $P = 0.04$) [Table 4].

Discussion

Bronchiectasis is a persistent lung disease identified by recurrent occurrence of infection and chronic

Table 4: Factors affecting invasive ventilation need during the Intensive Care Unit follow-up

Variable	Univariate analysis			Multivariate analysis		
	OR	95% CI	*P*	OR	95% CI	*P*
Bacterial proliferation in sputum culture	5.12	2.09-8.15	0.004	2.05	0.87-3.23	0.04
Radiologic disease extent	2.54	0.98-4.88	0.007	0.63	0.45-0.89	NS
PAP	3.81	1.96-5.35	0.005	0.94	0.75-1.05	NS

PAP: Pulmonary artery pressure, OR: Odds ratio, CI: Confidence interval, NS: Not significant

inflammation.[18] The latest studies supported that incidence,[19] hospital requirements,[20] and mortality[21] from NCFB were increasing, but there is minimal information about admission rates to the ICU and outcomes of patients with NCFB admitted to the ICU. In this study, respiratory failure was the principal reason for ICU admission and more than 90% of the patients were treated with NIV initially. This high rate of use is probably associated to our ICUs experience with NIV and the presence of AHRF in most patients. The mean pH and $PaCO_2$ were 7.29 and 72.1 mmHg, respectively. The NIV treatment success rate was higher and mortality rate was lower in the hypercapnic respiratory failure group than the hypoxemic respiratory failure group, and prior data advocate that NIV may be more effectual in hypercapnic than hypoxemic respiratory failure.[22] As the number of participants with hypoxemic respiratory failure was low, however, it would be inappropriate to make generalized conclusions based on our results. Sputum bacteriologic examination results were not different in the hypercapnic and hypoxemic respiratory failure groups.

Navaratnam *et al*. compared the annual increase in the number of ICU admissions from bronchiectasis and COPD and the results were 8% and 1%, respectively. Mortality (ICU and in-hospital) was higher in patients with bronchiectasis in contrast to those with COPD, particularly in individuals aged 70 years or above.[5] The present study revealed no relation between age and treatment success or mortality.

Nevertheless, few retrospective studies have focused on patients with bronchiectasis and ARF in the ICU. The ICU mortality of 14.6% in our cohort was in agreement with previous research outcomes. The studies by Dupont *et al*. (48 patients) and Alzeer *et al*. (35 patients) revealed ICU mortality of 19% and 34%, respectively.[9,23] Phua *et al*. reported in-hospital mortality rates of 25.8% for NIV and 26.9% for IV groups.[6]

Sputum bacteriology is an investigative test to determine the presence of bronchial infection during exacerbations in patients with bronchiectasis. Sputum culture is a noninvasive, uncomplicated, and cheap procedure. Bacterial infection agents were found in nearly half of the patients who were admitted to ICU for treatment of acute respiratory failure in the present study. Bacterial proliferation was the only predictor of treatment success in the multivariate analyses. Bacterial infection spurs the devastating cycle of bronchiectasis. The most frequently isolated organisms in patients with NCFB were *P. aeruginosa*, *S. pneumonia*, *H. influenza*, *A. baumannii*, and *E. coli*, respectively. Similar to our study, Pasteur *et al*. and Angrill *et al*. reported the most frequently isolated bacteria as H. *influenzae*, *P. aeruginosa*, Moraxella catarrhalis, *S. pneumoniae*, and *Staphylococcus aureus*.[13,24,25]

The management of patients with bronchiectasis with bacteria colonization is compelling, and a high ratio of the present curative evolution in bronchiectasis is concentrated on the management of *P. aeruginosa* infection.[26] Finch *et al*. reported that the most remarkable discovery within their analysis was the effect of *P. aeruginosa* on all-cause mortality. *P.* was also associated with increased exacerbation frequency by a rate of one exacerbation per patient per year and also a highly increased risk of hospital admissions.

Our study also showed that the patients with *Pseudomonas* proliferation in their sputum had higher number of hospital admissions in the last year. Venning *et al*. reported that the presence of *P. aeruginosa* was a risk factor for repeated exacerbations.[27] McDonnell *et al*. reported that *P. aeruginosa* is associated with greater persistent infection rates and more hospital admissions than *H. influenza*.[28] These findings confirmed the opinion that patients with *P. aeruginosa* need specific treatment to diminish the risk of long-term morbidity and mortality and that *P. aeruginosa* colonization condition should play an important role in the judgement of disease severity.[29]

The presence of chronic colonization by *P. aeruginosa* is the one of the variables of FACED score, which was developed to suggest the severity of bronchiectasis. Of all the diverse potential combinations, the parameter that essentially demonstrated the greatest capacity to independently prognosticate the probability of 5-year all-cause death was the presence of chronic colonization by *P. aeruginosa*.[30] Similarly, in the Bronchiectasis Severity Index, bacterial proliferation is an important prognostic factor and three patients with *P. aeruginosa* colonization scored as 3, and patients colonized with other pathogens scored as 1.[31]

Being one of the most common agents of infection, *Pseudomonas* species adversely affect the immune

system. Inflammation causes increased interleukin 8 synthesis, which in turn interacts with chemokine receptor CXCR1 to attract neutrophils to the site of inflammation. Proteases secreted by *Pseudomonas* impair CXCR1s functions and interfere with neutrophil aggregation. The increased rate of isolation of *Pseudomonas* in the sputum of bronchiectasis patients is associated with worsened disease severity, airway obstruction, and quality of life.[11]

In a study of patients with COPD, α-1-antitrypsin and bronchiectasis displayed a direct correlation between bacterial load of spontaneous sputum and multiple airway inflammation markers involving interleukin-8, myeloperoxidase, neutrophil elastase, and secretory leukocyte proteinase inhibitor.[10] Bacterial progression in bronchiectasis is the result of multiple acquired and inherited immune deficiencies, along with bacterial adaptations that contribute to chronic infection.[1]

We know from the literature that *P. aeruginosa* infection is more prevalent in patients with more severe bronchiectatic disease and causes lower quality of life and worse lung function,[10,11] and *P. aeruginosa* infection is linked with accelerated decline in lung function, more severe exacerbations, and greater systemic inflammation.[32]

Gursel reported that the coexistence of COPD with bronchiectasis caused an increase in the duration of ICU and hospital stays.[33] This may be explained by the fact that *P. aeruginosa* causes airway inflammation leading to more severe airflow limitation and prolonged ICU and hospital stays. Second, *P. aeruginosa* may cause weakness of the diaphragm. In a recent experimental study, Divangahi *et al*. demonstrated that persistent pulmonary infection with *P. aeruginosa* produced significant contractile dysfunction of the diaphragm.[34] This may also prolong the recovery period after acute respiratory failure and explain prolonged ICU stays in these patients.

Development of pulmonary hypertension is a poor prognostic sign in chronic lung disorders. Pulmonary hypertension is also known to be of importance in NCFB. The negative effects of hypoxemia in NCFB cause increased right ventricular volumes, after which right ventricular dysfunction occurs and systolic pulmonary artery pressure increases. In severe NCFB cases, capillary bed loss leads to the left to right shunt with afflicted perfusion. At the end of this process, cardiac function and pulmonary gas exchange deteriorate.[35] In the present study, PAP was found as an important factor for treatment success according to univariate analysis results. It was considered that the reason for statistically insignificant results in the multivariate analysis might be due to the high and similar PAP levels of the study group.

Our data showed a significant relationship with radiologic extension and treatment failure in the ICU. The radiologic extension of disease seems to be an important prognostic factor according to two particular prognostic indices that originated for bronchiectasis to assist clinical decision-making.[30,31] Multivariate Logistic regression analysis of a study showed that chest CT displayed bronchiectasis involving ≥3 lobes (OR: 3.179; 95% CI: [1.449–6.976]), high *P. aeruginosa* in sputum culture (OR: 3.227; 95% CI: [1.041-10.004]), and staying in the ICU (OR: 2.499; 95% CI: [1.301–4.801]) were associated with the increased number of acute exacerbation of bronchiectasis.[36]

Bronchiectasis exacerbations are inflammatory episodes and intensified systemic inflammation has previously been demonstrated, albeit in hospitalized patients.[37] CRP may provide a beneficial biomarker to follow-up inflammation throughout exacerbations. Murray *et al*. reported that the level of CRP was one of the most useful parameters to assess response to treatment of exacerbations of bronchiectasis.[38]

Conclusion

This study has shown the high prevalence of infection by sputum culture in patients with NCFB in the ICU. Positive bacterial sputum culture result was the most important factor for treatment success in patients with NCFB who were treated in the ICU for acute respiratory failure. This should be taken into account when apportioning medical care initiatives and planning respiratory services.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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