Int J Clin Exp Med 2019;12(5):6007-6013
www.ijcem.com /ISSN:1940-5901/IJCEM0088714

Original Article

Air impact-assisted intermittent subglottic secretion drainage improves the prognosis of chronic obstructive pulmonary disease patients with respiratory failure

Xinglei Wang[1], Yujuan Wei[2], Fengxia Li[3]

[1]Emergency Department, The Second Hospital of Shandong University, Jinan, Shandong, China; [2]Department of Pre-Hospital Care, People's Hospital of Rizhao, Rizhao, Shandong, China; [3]Department of Pediatric Kidney Disease, Shandong Provincial Hospital, Jinan, Shandong, China

Received November 20, 2018; Accepted December 12, 2018; Epub May 15, 2019; Published May 30, 2019

Abstract: Objective: To explore the efficacy of air impact-assisted intermittent subglottic secretion drainage (ISSD) on the blood-gas indicators, postoperative complications, and prognosis of chronic obstructive pulmonary disease (COPD) patients with respiratory failure. Methods: 128 COPD patients with respiratory failure and underwent invasive mechanical ventilation with tracheotomy were selected. The patients were randomly divided into the trial group (N=64) and the control group (N=64). The patients in the trial group were treated with air impact combined with intermittent subglottic secretion drainage (ISSD). The patients in the control group were treated with ISSD. Both air impact method and ISSD are commonly used in clinical practice to clear sputum. During treatment, we recorded the amount of airway secretion aspiration, positive rate of bacteria in the sputum smear, blood-gas indicators before and after sputum aspiration (including partial pressure of carbon dioxide [$PaCO_2$]) and partial pressure of blood oxygen [PaO_2]), vital signs per hour and the differences in vital signs before and after treatment (including heart rate, respiration, systolic blood pressure, and diastolic blood pressure), number of coughs, mechanical ventilation time, ventilator-associated pneumonia (VAP) incidence, and mortality rate of patients between the two groups. Results: In the trial group, the positive rate of the bacteria smear was significantly lower than that in the control group ($P<0.05$). After sputum aspiration, the $PaCO_2$ and PaO_2 in the trial group improved significantly than those observed in the control group ($P<0.05$). Before and after sputum aspiration, the vital signs of the patients in the trial group were significantly lower than those of the patients in the control group ($P<0.05$). Additionally, the number of coughs, mechanical ventilation time, VAP incidence, and mortality rate in the trial group were significantly decreased compared to those in control group ($P<0.05$). Conclusion: Following tracheotomy in COPD patients, air impact combined with ISSD can decrease the blood-gas indicators, incidence rates of cough and VAP, and mortality rate, and improve the prognosis of patients.

Keywords: Air impact, ISSD, blood-gas indicators, ventilator-associated pneumonia

Introduction

Invasive mechanical ventilation is currently an effective method in the clinical treatment of chronic obstructive pulmonary disease (COPD) patients with respiratory failure [1]. COPD is primarily characterized by airway limitation and is a partially irreversible pulmonary disease, and the resultant respiratory failure generally requires admission to the respiratory intensive care unit and administration of mechanical ventilation [2].

Nonetheless, tracheotomy-assisted mechanical ventilation is often accompanied by a series of complications, resulting in poor prognosis and a high mortality rate; moreover, ventilation-associated pneumonia, as the most severe complication, is also one of the major causes of the death of mechanical ventilation patients [3, 4]. According to previous reports, the mortality rate of patients receiving mechanical ventilation via tracheotomy can be as high as 57% [5]. It is also reported that aspiration of the bacteria distributed in the air sac or the surface of the mouth or throat serves as the major cause for the incidence of ventilator-associated pneumonia (VAP) [6]; thus, elimination of airway sputum is the main method for prophylaxis of VAP. At present, air impact and subglottic secretion

Table 1. Comparison of patient characteristics between the two groups

Factor	Trial group n=64	Control group n=64	X^2/t	P
Gender			0.032	0.858
Male	38 (59.38)	37 (57.81)		
Female	26 (40.63)	27 (42.18)		
Age (years old)			0.031	0.860
≤ 70	33 (51.56)	32 (50.00)		
> 70	31 (48.44)	32 (50.00)		
Whether smoking			0.031	0.860
Yes	31 (48.44)	30 (46.88)		
No	33 (51.56)	34 (53.13)		
Health status score	17.22±3.29	17.83±3.41	1.030	0.305
Coagulation				
PT (s)	14.11±1.61	13.97±1.46	0.515	0.607
APTT (s)	33.78±2.91	34.09±2.63	0.632	0.528
TT (s)	16.21±1.09	15.99±0.87	1.262	0.209
FIB (g/L)	2.98±0.23	3.01±0.31	0.622	0.535
Whether it is coma			0.034	0.850
Yes	21 (32.81)	20 (31.25)		
No	43 (67.19)	43 (68.75)		
Spontaneous breathing			0.034	0.853
Yes	42 (65.63)	41 (64.06)		
No	22 (34.38)	23 (35.94)		

drainage are common methods used in clinical practice to eliminate sputum. Meanwhile, air impact, in comparison with sputum aspiration in the mouth, nose, or throat, is more efficient in eliminating secretions in the airway, with a significant decrease in the incidence rate of complications in the lung [7]. Moreover, when compared to the regular aspiration of sputum, subglottic secretion drainage excels in removing secretions in the air sac, with a lower incidence rate of VAP [8]. However, little information is available regarding elucidation of the effect of air impact-assisted intermittent subglottic secretion drainage (ISSD) on respiratory failure patients who receive mechanical ventilation. According to previous studies on COPD, accumulating evidence has demonstrated the association between prognosis and blood-gas indicators in COPD [9, 10]. Christensen et al. [11] reported that differences in blood-gas indicators scarcely altered the outcome of patients, while Eneff et al. [12] observed that a high partial pressure of carbon dioxide ($PaCO_2$) (> 50 mmHg) may account for the increased mortality rate.

Thus, in addition to focusing on the effect of air impact-assisted ISSD on the complications of mechanical ventilation, we also investigated the differences in blood-gas indicators and prognosis in COPD patients, so as to provide a more efficient method of sputum aspiration for invasive ventilation support in COPD patients with respiratory failure.

Materials and methods

General data

128 COPD patients with respiratory failure who received mechanical ventilation via airway intubation in the intensive care unit of our hospital were selected. The patients comprised 66 males and 62 females, aged 73.61±9.76 years; there were 38 patients with respiratory failure caused by pneumonia, 28 by cerebrovascular disorder, 42 by chronic heart failure, and 21 by other factors.

The patients were randomly divided into the trial group (N=64) and the control group (N=64). All patients underwent invasive mechanical ventilation with tracheotomy. The patients in the trial group were treated with air impact combined with intermittent subglottic secretion drainage (ISSD). The patients in the control group were treated with ISSD. The inclusion criteria were as follows: patients with symptoms or vital signs conforming to the diagnostic criteria of respiratory failure [4, 13]; patients with COPD; and those who underwent invasive mechanical ventilation ≥48 hrs with tracheotomy. The exclusion criteria were as follows: patients with other severe liver and kidney dysfunctions or tumors, and patients with communication difficulties. This study was approved by the Ethics Committee of the Shandong Provincial Hospital, and all subjects and their relatives given their written informed consent before participating in the study, and accorded to cooperate with the medical staff to accomplish the diagnosis and treatment. Comparisons of the general data of patients, including age and gender, between the two groups indicated that the differences had no statistical significance ($P > 0.05$) (**Table 1**). This

study has been approved by the Ethics Committee of Shandong Provincial Hospital. All study participants had given their written informed consent before participating in the study.

Methods

Nurses who were responsible for sputum elimination from the airway were trained in air impact combined with ISSD and regular ISSD methods. Intervention begins after the patient has undergone mechanical ventilation through the tracheal intubation, and the operation was strictly performed under sterile condition. The pressure of the cuff was maintained between 26 and 28 cm H_2O (1 cm H_2O=0.098 kPa). Oral nursing care was performed three to four times per day for each patient, and the position of the patient was required to be changed every 2-3 h, with the head of bed being lifted by approximately 35-45°. The patients in the control group then received regular ISSD: in brief, the negative pressure of the suction device was set to 60 mmHg, and the orifice and caps of the subglottic secretion drainage tube were sanitized using 0.5% iodophor; the suction device was then connected to prepare for the elimination of sputum every 2 h (1 h/round). The patients in the trial group received air impact combined with ISSD to eliminate the airway sputum. In brief, after the sufficient elimination of sputum in the airway and secretion in the mouth and nose via regular ISSD, air impact was implemented by two nurses. A tracheal catheter was connected to the plain respiratory air sac for auxiliary ventilation, which was squeezed by a nurse at the end of inspiration; simultaneously, the other nurse was required to fill the air sac with air immediately at the end of expiration, and the oral or nasal secretions were then removed again. This process was repeated two or three times until the airway sputum and secretion were fully eliminated. The amount of eliminated sputum in the two groups, along with the color, was recorded daily. The suction ends with the removal of mechanical ventilation.

Outcome measures

We observed and recorded the following outcome measures in the two groups: the amount of eliminated sputum and the positive bacteria rate in the sputum smear; blood-gas indicators before and after sputum elimination, including $PaCO_2$ and partial pressure of blood oxygen (PaO_2); vital signs every hour and the differences in vital signs before and after sputum elimination, including heart rate, respiratory rate, systolic blood pressure, and diastolic blood pressure, as well as the number of coughs and mechanical ventilation time; incidence rate of VAP, and mortality rate. VAP was diagnosed with the following criteria [14]: a) onset time: within 48 h of mechanical ventilation, b) infiltrative shadow in chest X-ray image, c) total amount of white blood cells in peripheral blood > 10×10^9/L or <4×10^9/L, d) temperature > 38°C, and e) purulent secretion in airway. Patients satisfying two or more of the above criteria could be diagnosed with VAP. Among them, blood gas indicators and postoperative complications are the main outcome measurements. The intervention is terminated when the patient died or the ventilator was removed.

Statistical methods

SPSS 18.0 software (SPSS Inc., Chicago, IL, USA) was used to perform the statistical analysis. Kolmogorov-Smirnov method was used to verify whether the data conforms to the normal distribution. Enumeration data were compared with a chi-square test, while measurement data are presented as mean ± standard deviation and pairwise t test was used to compare data between groups while independent t test was used for between-group comparison. $P<0.05$ indicated statistical significance.

Results

Comparison of the amount of sputum elimination in the airway and the positive bacteria rate in the sputum smear

After examination, it was found that amount of sputum elimination from the airway of patients conforms to normal distribution ($P > 0.10$). The amount of sputum elimination from the airway of patients in the trial group and the control group was 107.72±31.27 mL/d and 110.35± 32.19 mL/d, respectively, but the difference was not significant ($P > 0.05$). The positive bacteria rate in the sputum smear in the trial group

Table 2. Comparison of Total Amount of Respiratory Sputum and Positive Rate of Bacterial Smear between the Two Groups

Factor	Trial group N=64	Control Group N=64	X^2/t	P
Respiratory Sputum Suction Total (mL/d)	107.72±31.27	110.35±32.19	0.469	0.640
Bacterial Smear Positive Rate	20.31%	35.94%	3.865	=0.019

Table 3. Comparison of $PaCO_2$ before and after sucking in the two groups (kPa)

Time	Trial group n=64	Control group n=64	t	P
Before sucking	6.93±0.31	6.98±0.28	0.958	0.340
After sucking	5.12±0.27	6.19±0.22	24.58	<0.001
t	9.121	8.453	-	-
P	<0.001	<0.001	-	-

Table 4. Comparison of PaO_2 before and after sucking in the two groups (kPa)

Time	Trial group n=64	Control group n=64	t	P
Before sucking	4.12±0.19	4.09±0.21	0.848	0.398
After sucking	5.87±0.26	4.75±0.25	24.84	<0.001
t	9.137	9.528	-	-
P	<0.001	<0.001	-	-

was 20.31%, which was significantly lower than the 35.93% observed in the control group (P<0.05) (**Table 2**).

Comparison of the blood-gas indicators before and after sputum elimination

Before sputum elimination, the patients in the trial group had a $PaCO_2$ and PaO_2 of 6.93±0.31 kPa and 4.12±0.19 kPa, respectively, while after sputum elimination, these indicators were 5.12±0.27 kPa and 5.87±0.26 kPa, respectively. In the control group, the $PaCO_2$ and PaO_2 of patients before sputum elimination were 6.98±0.28 kPa and 4.09±0.21 kPa, respectively, while after sputum elimination, these indicators were 6.19±0.22 kPa and 4.75±0.25 kPa, respectively. Thus, after sputum elimination, patients in the experiment group exhibited better $PaCO_2$ and PaO_2 than did those in the control group (P<0.05) (**Tables 3** and **4**).

Comparison of the differences in vital signs before and after sputum elimination

Before and after sputum elimination, the differences in heart rate, respiratory rate, systolic blood pressure, and diastolic blood pressure of patients in the trial group were 6.75±1.08 bpm, 4.12±0.63 breaths/min, 8.95±2.71 mmHg, and 7.12±2.98 mmHg, while those in the control group were 11.63±1.48 bpm, 7.13±0.76 breaths/min, 14.07±3.51 mmHg, and 10.19±3.27 mmHg. Thus, the operation posed less influence on the vital signs of patients in the trial group than on those in the control group (P<0.05) (**Table 5**).

Comparison of the number of coughs and mechanical ventilation time

It was found that mechanical ventilation time conforms to normal distribution (P > 0.10). For patients in the trial group, the average number of coughs and mechanical ventilation time were 4.12±1.23 times and 128.41±39.67 h, while for those in the control group, these averages were 6.87±1.66 times and 149.35±41.69 h. Hence, the number of coughs and mechanical ventilation times of patients in the trial group were significantly lower or shorter than those in the control group (P<0.05) (**Table 6**).

Incidence rate of VAP within 7 days and mortality rate

In the trial group, nine patients were diagnosed with VAP within 7 days, and ten patients died, among which seven patients died from VAP. In the control group, 19 patients were diagnosed with VAP, and 20 died, 15 of whom from VAP. In the trial group, the incidence rate of VAP and the mortality rate were 14.06% and 15.63%, which were significantly lower than the 29.69% and 31.25% observed in the control group (P<0.05) (**Table 7** and **Figure 1**).

Discussion

For the emergence of respiratory failure caused by any factor, mechanical ventilation is the major rescue and treatment measure [15]. However, after the establishment of arti-

Table 5. Comparison of vital signs change before and after sucking

Vital Signs	Trial group N=64	Control Group N=64	t	P
Heart Rate (beat/min)	6.75±1.08	11.63±1.48	21.31	<0.001
Breathe (time/min)	4.12±0.63	7.13±0.76	24.39	<0.001
Systolic Blood Pressure (mmHg)	8.95±2.71	14.07±3.51	9.237	<0.001
Diastolic Blood Pressure (mmHg)	7.12±2.98	10.19±3.27	5.551	<0.001

Table 6. Comparison of the frequency of coughing and the time of mechanical ventilation between the two groups

	Trial group N=64	Control Group N=64	t	P
Number Of Coughs	4.12±1.23	6.87±1.66	10.65	<0.001
Mechanical Ventilation Time (h)	128.41±39.67	149.35±41.69	2.911	<0.050

Table 7. Incidence of VAP within 7 days and mortality during treatment (%)

Project	Trial group N=64	Control Group N=64	X^2	P
VAP	9 (14.06)	19 (29.69)	4.571	<0.050
Mortality Rate	10 (15.63)	20 (31.25)	7.082	<0.050

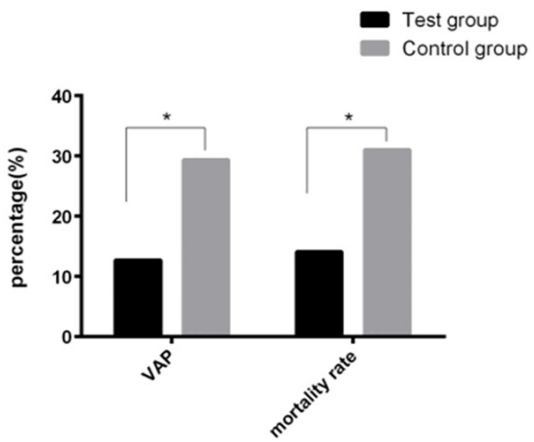

Figure 1. Incidence of ventilator-associated pneumonia (VAP) within 7 days of mechanical ventilation and mortality during treatment. The incidence of VAP within 7 days of mechanical ventilation and the mortality rate during treatment in the trial group were lower than those in the control group (P<0.05).

ficial airways, the original physiological barrier in the airway is destructed, leading to poor motivation of the cilia on the airway wall, and resulting in further declines in the evacuation of sputum by coughing and swallowing function. The resultant failure in effective elimination of secretion in the airway and pharynx oralis further facilitates the entrance of pathogens into the lower respiratory airway, giving rise to a series of complications, including VAP [16, 17]. In addition, the blood-gas indicators of respiratory failure patients also reflect the status and prognosis [18]. It has been evidenced that once the blood-gas indicators are stabilized, the prognosis of patients with respiratory failure may be effectively improved, and well-controlled blood-gas indicators also secure the recovery and ventilator weaning of patients [19]. Air impact and subglottic secretion drainage are popular methods used to eliminate the sputum of patients receiving mechanical ventilation, but are also limited in different aspects in spite of their efficiency in eliminating airway secretions [20, 21]. For example, air impact is inferior during the operation [22], while subglottic secretion drainage may induce damage to the airway mucosa [23]. Thus, in this study, air impact was combined with ISSD, and we aimed to investigate the changes in blood-gas indicators and the efficacy in decreasing postoperative complications in COPD patients with respiratory failure.

First, we compared the total amount of sputum elimination and the positive bacteria rate in the sputum smear of patients in the experimental and control groups, and found no significant difference in the amount of sputum elimination between the two groups (P > 0.05). However, the positive bacteria rate in the experiment group was significantly lower than that in the control group (P<0.05), suggesting that air impact-assisted ISSD can reduce bacterial reproduction. Thereafter, we compared the blood-gas indicators, fluctuations in vital signs, number of coughs, and mechanical ventilation times between the two groups, and the results indicated that the reduction in the blood-gas indicators in the trial group was markedly more significant than that in the control group (P<0.05). Minor fluctuations were observed in

the vital signs (P<0.05), and the number of coughs and mechanical ventilation time of patients in the trial group were significantly lower or shorter than those in the control group (P<0.05), suggesting that air impact-assisted ISSD can improve the indicators of patients more efficiently and stably, and also reduce the number of coughs and mechanical ventilation time of patients. According to our speculation, the combination of these methods exerted less influence on the humidity and temperature of the airway, and simultaneously mitigated the damage to the airway mucosa, thereby easing the tensed airway mucosa. Consistent with our results, previous evidence has demonstrated that the alleviated stimuli to the airway mucosa can reduce the effect on the vital signs and mitigate coughing, which is more conducive to the recovery of blood-gas indicators [24]. Finally, we also compared the incidence rate of VAP within 7 days and the mortality rate of patients within 90 days of mechanical ventilation between the two groups, and found that the incidence rate of VAP and mortality rate of patients in the trial group during treatment were all significantly lower than those in the control group, suggesting that air impact-assisted ISSD can more effectively decrease the incidence rate of VAP and mortality rate of patients. Current studies have identified accidental inspiration as one of the major factors contributing to the incidence of VAP [25]. VAP can result in the failure of mechanical ventilation to prolong the hospitalization time of patients [26], or even result in death [27]. Thus, preventing the inspiration of airway secretions into the respiratory tract is believed to be a key factor in prophylaxis of VAP.

In conclusion, the application of air impact-assisted ISSD in patients with invasive mechanical ventilation can efficiently reduce the blood-gas indicators of patients, with a lower incidence rate of complications and mortality rate of patients, and significant improvement in prognosis. However, due to the lack of evidences supporting the application of air impact-assisted ISSD in invasive mechanical ventilation, we suggest that more efforts should be devoted to in-depth comparisons and studies of this aspect.

Disclosure of conflict of interest

None.

Address correspondences to: Fengxia Li, Department of Pediatric Kidney Disease, Shandong Provincial Hospital, No.324, Jingwu Weiqi Road, Jinan 250021, Shandong, China. Tel: +86-0531-68777831; E-mail: fengxialiyx@163.com

References

[1] Fiorino S, Bacchi-Reggiani L, Detotto E, Battilana M, Borghi E, Denitto C, Dickmans C, Facchini B, Moretti R and Parini S. Efficacy of noninvasive mechanical ventilation (niv) in the general ward in patients with chronic obstructive pulmonary (copd) disease admitted for hypercapnic acute respiratory failure (arf) and ph<7.35: a feasibility pilot study. Int Med J 2015; 45: 527-537.

[2] Pacilli AM, Valentini I, Carbonara P, Marchetti A and Nava S. Determinants of noninvasive ventilation outcomes during an episode of acute hypercapnic respiratory failure in chronic obstructive pulmonary disease: the effects of comorbidities and causes of respiratory failure. Biomed Res Int 2014; 2014: 976783.

[3] Costa JB, Costa AL, Torres F, Galdino da Silva AdF and Terra Junior. The risk factors and the main microorganisms related to pneumonia associated with mechanical ventilation at the adult ICU. Revista cientifica Da faculdade De educacao e Meio ambiente 2016; 7: 80-92.

[4] Rathod A, Soni S, Patel K, Vegad M, Kumari M and Gandhi P. Prevalence of various bacterial pathogens causing ventilator associated pneumonia (VAP) isolated from ICU in tertiary care hospital. National Journal of Integrated Research in Medicine 2017; 8.

[5] Blanch L, Villagra A, Sales B, Montanya J, Lucangelo U, Luján M, García-Esquirol O, Chacón E, Estruga A, Oliva JC, Hernández-Abadia A, Albaiceta GM, Fernández-Mondejar E, Fernández R, Lopez-Aguilar J, Villar J, Murias G, Kacmarek RM. Asynchronies during mechanical ventilation are associated with mortality. Intensive Care Med 2015; 41: 633-641.

[6] Kalil AC, Metersky ML, Klompas M, Muscedere J, Sweeney DA, Palmer LB, Napolitano LM, O'Grady NP, Bartlett JG, Carratalà J, El Solh AA, Ewig S, Fey PD, File TM Jr, Restrepo MI, Roberts JA, Waterer GW, Cruse P, Knight SL, Brozek JL. Management of adults with hospital-acquired and ventilator-associated pneumonia: 2016 clinical practice guidelines by the infectious diseases society of America and the American thoracic society. Clin Infect Dis 2016; 63: 575-82.

[7] Zhang X. Influence of air impact methods clearing out the subballonet secretion on ventilator-associated pneumonia. Chinese Journal of Primary Medicine and Pharmacy 2014; 21: 33-34.

[8] Liu F, Fei H, Fangbao H, Wang Y and Dai L. Effects of subglottic secretion drainage at different intervals on ventilator-associated pneumonia. Chinese Journal of Practical Nursing 2017; 33: 2280-2283.
[9] Rennis DK and Krishnakumar EV. Role of initial arterial blood gas variations in predicting the outcome of pneumonia patients with type I/II respiratory failure. International Journal of Advances in Medicine 2017; 3: 313-318.
[10] İlhan S, Günay R, Özkan S, Güvenç TS and Yurtsever N. Arterial blood gas analysis in chronic obstructive pulmonary disease patients undergoing coronary artery bypass surgery. Turk Thorac J 2016; 17: 93.
[11] Christensen S, Rasmussen L, Horváth-Puhó E, Lenler-Petersen P, Rhode M and Johnsen SP. Arterial blood gas derangement and level of comorbidity are not predictors of long-term mortality of COPD patients treated with mechanical ventilation. Eur J Anaesthesiol 2008; 25: 550-6.
[12] Seneff MG, Wagner DP, Wagner RP, Zimmerman JE, Knaus WA. Hospital and 1-year survival of patients admitted to intensive care units with acute exacerbation of chronic obstructive pulmonary disease. JAMA 1995; 274: 1852-7.
[13] Lichtenstein DA and Meziere GA. Relevance of lung ultrasound in the diagnosis of acute respiratory failure*: the BLUE protocol. Chest 2008; 134: 117-25.
[14] Charles MP, Kali A, Easow JM, Joseph NM, Ravishankar M, Srinivasan S, Kumar S and Umadevi S. Ventilator-associated pneumonia. Australas Med J 2014; 7: 334-44.
[15] Maung AA and Kaplan LJ. Acute respiratory failure and mechanical ventilation. Surgical Critical Care and Emergency Surgery: Clinical Questions and Answers 2018; 79-88.
[16] Bassi GL, Ferrer M, Marti JD, Comaru T and Torres A. Ventilator-associated pneumonia. Semin Respir Crit Care Med 2014; 35: 469-81.
[17] Gunasekera P and Gratrix A. Ventilator-associated pneumonia. Bja Education 2015; 16: 198-202.
[18] Stradling J. Effects of the administration of O2 on ventilation and blood gases in patients with chronic obstructive pulmonary disease during acute respiratory failure. Am Rev Respir Dis 1980; 122: 747-754.
[19] Mortensen JD. Intravascular oxygenator: a new alternative method for augmenting blood gas transfer in patients with acute respiratory failure. Artif Organs 1992; 16: 75-82.
[20] Guo C, Chu Y and Zhao L. Effect evaluation of preventing ventilator associated pneumoia of patients with the oral trachea can-nula by air impact method to remove airbags retentate. Chinese Journal of Practical Nursing 2015; 31: 2135-2137.
[21] Jin W. Application of different subglottic attraction in the prevention of ventilator-associated pneumonia and their affect on the airway mucosa. Chinese Journal of Postgraduates of Medicine 2014; 37: 26-28.
[22] Yumeng H, Ying W, Xiaohui L, Juanjuan W and Yinghong X. Effects of continuous aspiration of subglottic secretions to prevent ventilator associated pneumonia: a meta analysis. Journal of Ursing 2015; 30: 98-101.
[23] Greene R, Thompson S, Jantsch H, Teplick R, Cullen D, Greene E, Whitman G, Hulka C and Llewellyn H. Detection of pooled secretions above endotracheal-tube cuffs: value of plain radiographs in sheep cadavers and patients. AJR. AJR Am J Roentgenol 1994; 163: 1333-7.
[24] Vitacca M, Clini E, Rubini F, Nava S, Foglio K and Ambrosino N. Non-invasive mechanical ventilation in severe chronic obstructive lung disease and acute respiratory failure: short- and long-term prognosis. Intensive Care Med 1996; 22: 94-100.
[25] Krüger S, Frechen D and Ewig S. Prognosis of ventilator-associated pneumonia: what lies beneath. Eur Respir J 2011; 37: 486-8.
[26] Craven DE, Hudcova J and Rashid J. Antibiotic therapy for ventilator-associated tracheobronchitis: a standard of care to reduce pneumonia, morbidity and costs? Curr Opin Pulm Med 2015; 21: 250-9.
[27] Pneumatikos IA, Dragoumanis CK and Bouros DE. Ventilator-associated pneumonia or endotracheal tube-associated pneumonia? An approach to the pathogenesis and preventive strategies emphasizing the importance of endotracheal tube. Anesthesiology 2009; 110: 673-80.