Original Article
Subglottic secretion drainage and semi-recumbent position for preventing ventilator associated pneumonia

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Abstract: Background: To reduce the incidence rate of ventilator-associated pneumonia (VAP) in the mechanical ventilation patients has become an immediate area of research focus in the critical care medicine. Objectives: To assess the efficacy of subglottic secretion drainage combined with semi-recumbent position in preventing ventilator-associated pneumonia. Methods: Patients admitted to our ICU were randomly assigned to groups of semi-recumbent position (n=40), subglottic secretion drainage (n=39), subglottic secretion drainage combined with semi-recumbent position (n=43) and group of control (n=42). Three experimental groups receive additional intervention of semi-recumbent position or/and subglottic secretion drainage respectively. These groups were compared with respect to incidence and mortality of VAP, duration of mechanical ventilation, and length of ICU stay. Results: Incidence of VAP is reduced to all the 3 experimental groups. The combined group has a lower incidence of VAP than that in the other 2 experimental groups. However, the mortality of VAP is not significantly different among groups. Discussion: Combination of subglottic secretion drainage and semi-recumbent position can reduce the incidence of VAP and shorten the duration of mechanical ventilation.

Keywords: Subglottic secretion drainage, semi-recumbent position, ventilator-associated pneumonia

Introduction

Ventilator-associated pneumonia (VAP), the most common complication in critically ill patients under mechanical ventilation [1, 2] is developed mainly because of aspiration of gastric reflux and infected oropharyngeal secretions. Previous studies reported the incidence of VAP ranges from 9% to 69%, relative mortality from 30% to 50% [3-6].

Semi-recumbent position is considered to be the most economical therapeutic method of reducing the incidence of VAP. With an elevated at an angle of 30 to 45 at the head of the bed and the support under knees of 10 to 20, semi-recumbent position could reduce the incidence of VAP by 15-30% according to previous studies [7, 8]. Disturbance of normal airway mucosa function by tracheal intubation promotes the retention of oropharyngeal secretion in the interspace between glottis and tracheal tube cuff. The stranded secretion provides an enabling environment for the growth of bacteria due to the poor antibiotic concentrations in it.

Previous studies on the subglottic secretion drainage (SSD) and untreated controls draw a conclusion of reducing the incidence of VAP by SSD [9]. However, there has been lack of research on the issue of combination of semi-recumbent position and SSD.

Patients and methods

Data collection

164 patients admitted to our ICU from March 2011 to June 2013 with an expected duration of mechanical ventilation for ≥48 h were enrolled in our study (97 male, 67 female, and age from 18 to 81years old with an average of 52.5±12.5). Of which 46 cases with the primary diseases of COPD, 21 cases of severe bronchial asthma, 27 cases of postoperative infection with respiratory failure, 17 cases of severe pneumonia, 18 cases of ARDS, 17 cases of heart failure, 12 cases of cerebrovascular disease, 6 cases after operation for heart diseases. Randomization was performed by dividing the last digit of the medical record number by 4

Table 1. Clinical characteristics of the control and experimental groups

Groups	Number of cases	Age (years)	Sex (cases)		APACHEII scores (mean ± SD)
			Male	Female	
Control	42	52.4±13.2	25	17	17.4±6.7
Semi-supine position	40	51.8±12.1	24	16	19.5±5.9
Subglottic secretion drainage	39	51.8±12.0	23	16	18.7±6.1
Combined group	43	54.5±12.3	25	18	19.2±7.3

and so 4 groups are formed as follows: control group, semi-supine position group, subglottic secretion drainage group and semi-supine position group with subglottic secretion drainage group. The four groups are similar in age, sex, primary disease and APACHEII scores (P>0.05). The clinical data of all the subjects are shown in **Table 1**.

Diagnosis criteria

The diagnosis for VAP referred to the Hunter's diagnosis criteria: duration of mechanical ventilation for ≥48 h or within 48 h after weaning, there are: (i) fever of >38.3°C, (ii) blood leukocyte count of >10 × 109/L, (iii) a new infiltrate on chest X-ray, (iv) purulent tracheobronchial secretions, (v) more than one potentially pathogenic organism was isolated from deep bronchus sputum. Establishing the diagnosis of VAP should at least satisfy 4 criteria above [10, 11].

Intervention

Patients in the 4 groups are managed by professionally trained ICU medical supervisions. All patients receiving mechanical ventilation are given series of routine nursing including placement of gastric tube in order to assure the enteral hyperalimentation, oral decontamination 4 times per day, connection of sealed suction tube for sputum drainage according to the operation instruction, hand hygiene and prevention of deep venous thrombosis. In addition, subglottic secretion drainage and wash are performed every 2 hours on patients in the subglottic secretion drainage group with washable ETT after estimation of whether gastric retention or not with gastric juice suction every 4 hours and the drainage quantity was recorded. All patients in the semi-recumbent position should strictly have the head of the bed (HOB) elevated at an angle of 30 to 45 and the support under knees of 10 to 20 unless recumbent position contraindicated. Patients in the combined group are given both strategies of semi-

recumbent position and subglottic secretion drainage.

At the first day when patients receiving mechanical ventilation, all the patients are given beside chest X-ray examination, whole blood cell analysis, and microorganism check and drug sensitive test of secretion from deep artificial airway collected with disposable aseptic suction catheter carrying specimen collection bottle. All items are reexamined every 2 days thereafter under mechanical ventilation. Within 48 hours after weaning, chest X-ray, blood cell analysis, sputum culture and drug sensitive test were checked again. Temperature and sputum was monitored and recorded every day.

Outcome measurements

Incidence of VAP under condition of duration of mechanical ventilation for ≥48 h or within 48 h after weaning, mortality of VAP, duration of mechanical ventilation and length of ICU stay.

Statistical analysis

Analysis was performed with the statistical software SPSS (version 13.0). We used x^2 test for categorical variables and the Student's t test for continuous variables where P<0.05 was considered indicative of statistical heterogeneity. Continuous variables were presented in the form of mean ± SD.

Results

Five patients were excluded from our study because they could not execute the semi-recumbent position due to the instability of hemodynamics 72 h after mechanical ventilation.

Incidence and mortality of VAP at day 4, 6, 8, 10 of mechanical ventilation

Compared with control, patients who received subglottic secretion drainage had an obvious

Table 2. Incidence of VAP

Groups	Included examples	Cases of VAP (%)				Mortality of VAP
		Day 4	Day 6	Day 8	Day 10	
Control	42	2 (4.76)	7 (16.67)	12 (28.57)	15 (35.71)	7 (46.67)
Semi-supine position	38	0 (0.00)	4 (10.53)$^\Delta$	7 (18.42)$^\Delta$	11 (28.95)$^\Delta$	5 (45.45)
Subglottic secretion drainage	39	0 (0.00)	3 (7.69)$^\Delta$	9 (23.08)$^\Delta$	12 (30.77)$^\Delta$	5 (41.67)
Combined group	40	0 (0.00)	2 (5.00)$^\Delta$	5 (12.50)$^{\Delta,*}$	7 (17.50)$^{\Delta,*}$	3 (42.86)

Note: 2 patients in the semi-supine position group and 3 patients in the subglottic secretion drainage group were excluded from our study because of their incapable of semi-recumbent position due to the instability of hemodynamics 72 h after mechanical ventilation. The superscript triangle ($^\Delta$) indicates significant difference between control group and experimental groups ($P<0.05$), and the superscript asterisk (*) between semi-supine position group and subglottic secretion drainage group ($P<0.05$).

Table 3. Duration of mechanical ventilation and length of ICU stay

Groups	Cases	Duration of MV (days)	Length of ICU stay (days)
Control	42	10.21±4.75	16.35±6.64
Semi-supine supine	38	8.64±3.28$^\Delta$	12.21±5.03$^\Delta$
Subglottic secretion drainage	39	7.81±4.06$^\Delta$	11.62±5.82$^\Delta$
Combined group	40	7.22±3.73$^\Delta$	9.23±3.72$^{\Delta,*}$

Notes: The superscript asterisk (*) indicates significant difference between control group and groups intervened with semi-supine supine and subglottic secretion drainage alone ($P<0.05$), and the superscript triangle ($^\Delta$) between control group and experimental groups ($P<0.05$).

reduced risk of VAP at MV day 6 (P<0.05). Furthermore, those intervened both with subglottic secretion drainage and semi-recumbent position had a lower incidence of VAP than those that subglottic secretion drainage was adopted alone at day 8 of MV. However, as the duration of mechanical ventilation prolonged, incidence of VAP in all groups increased, and once patients developed VAP, the mortality among groups has no significant difference (P>0.05). For details, see **Table 2**.

Duration of mechanical ventilation and length of ICU stay

The mean duration value of mechanical ventilation are 8.64±3.28 days and 7.81±4.06 days for patients received semi-recumbent position respectively and subglottic secretion drainage, both are lower than that of the control group (P<0.05). To the group received combined treatment, the value is 7.22±3.73 days, which is also lower than that of the control group (P<0.05), while when compared with groups the intervene administered alone, the duration of mechanical ventilation is no significant difference. Length of ICU stay are 12.21±5.03 days and 11.62±5.82 days for semi-recumbent

position group and subglottic secretion drainage group respectively, shorten than that of the control group (16.35±6.64 days), and to the combined group, the value is 9.23±3.72 days, lower than that of the control group and also the other 2 experimental groups that the intervene adopted alone. This may be caused by the lower incidence of VAP within 48 h after weaning in the combined group. For details, see **Table 3**.

Relationship between the amount of subglottic secretion drainage and the development of VAP

The amount of secretion drainage during 24 h was 37.82±9.21 ml and 35.47±11.03 ml for subglottic secretion drainage group and combined group respectively, was no significant difference. This indicates semi-recumbent position has no effect on the amount of subglottic secretion drainage. While a retrospective analysis was found that the amount of secretion drainage to patients with no VAP (87 cases) was much more than that of patients with VAP (30 cases), and they are 40.36±13.30 ml/24 h and 21.63±7.26 ml/24 h separately.

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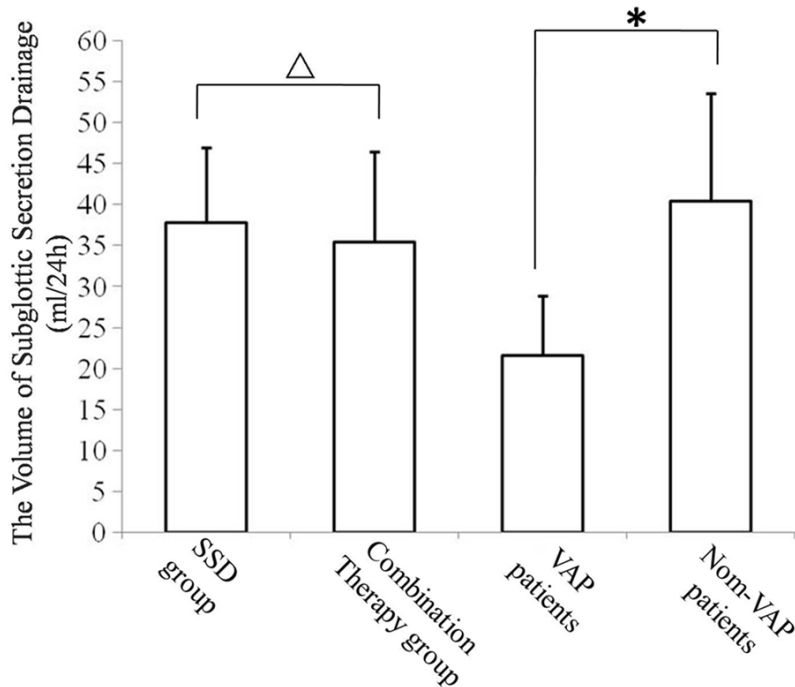
Figure 1. Retrospective analysis of the volume of subglottic secretion drainage (ml/24 h). Note: The asterisk (*) indicates significant differences ($P<0.05$) between two groups, while the triangle Δ not ($P>0.05$).

drainage to patients with no VAP (87 cases) was much more than that of patients with VAP (30 cases), and they are 40.36±13.30 ml/24 h and 21.63±7.26 ml/24 h separately. For details, see **Figure 1**.

Discussion

VAP is the most common complication in critically ill patients requiring mechanical ventilation. It developed mainly because of aspiration of gastric reflux and infected oropharyngeal secretions. Artificial airway built under mechanical ventilation damage the clearance function of the mucociliary system, destroying the natural defense mechanism of upper respiratory tract. Meanwhile, patients' weak swallowing function leads to a gap between hypolarynx and ETT cuff, where the oropharyngeal secretions pooled and bacteria colonized. Chest X-ray found it was about 3-15 ml. Gastric intubation loosed the lower esophagus sphincter and inhibited its contraction, delayed gastric emptying, increased intragastric pressure and content, leading to the reflux of gastric contents and the translation of gastric pathogens into lower respiratory tract which was associated with the pathogenesis of the VAP [12]. In a report by Kollef and colleagues, secretion in

subglottis was found to be homologous with the gastric contents, and the ETT provide a direct conduit for pathogens colonized in stomach to reach the lower airways, causing pulmonary infection [13].

Washable ETT, as an effective and feasible strategy to prevent VAP, it cuts off the infectious routine from stomach to pharynx and lower airway, reduced the pathogen translation to and colonization of oropharynx [14]. Pathogens can also colonized in gap between the cuff and oropharynx and glottis, contaminative colonization flow into the lung bypass the cuff causing infection because of patients' breath, transient decreased cuff pressure and change of the body position and, as a result, the risk of VAP. The side tube on the washable ETT can remove retention above the cuff directly; it was adapted to drainage and wash the secretion above the cuff every 2 hours. As secretion and colonized pathogens removed away, leakage across ETT cuff and translocation of oropharyngeal pathogens into the lungs was reduced, and the retrograde infectious routine from stomach to oropharynx was cut off, which prevented aspiration of contaminated secretion, sequentially, avoided the occurrence of VAP. Removal of gastric juice every 4 hours avoided the aimless feeding to strength nutrition and gastric retention, reduced gastric volume and pressure, gastroesoghageal reflux and aspiration of gastric contents, thus preventing the happening of VAP [15]. Our study demonstrated lower incidence of VAP at MV days 4, 6, 8 and 10 in the group of subglottic secretion drainage than that in the control group, this indicated the efficacy of subglottic secretion drainage and wash in the prevention of VAP. However, for prolonged mechanically ventilated patients, the incidence of VAP increased.

Semi-recumbent position can bring down the incidence of VAP by reducing reflux and aspiration of secretion in stomach, oropharynx, naso-

pharynx. In addition, it displace the diaphragm downward, increase the chest capacity, this is beneficial to lung recruitment, improvement of oxygen saturation, and reduction in the need of mechanical ventilation [16]. The semi-recumbent position has been endorsed by the Institute for Healthcare Improvement (IHI) as one of the most effective and feasible strategies to prevent VAP. The proportion that homogeneous bacteria isolated from gastric juice, bronchus secretion and throat swab is 35% to patients adopted the semi-recumbent position and 70% to patients the supine position. It indicated that maintaining the internal cuff pressure within the recommended range could not prevent pulmonary aspiration effectively [17]. Cai et al compared the secretion and microorganism from pharynx, stomach and trachea of the same patient in different recumbent position, she found in the supine position, the mean radio-activity count was significantly higher than that in the semi-recumbent position, which demonstrated semi-recumbent position can reduce the susceptibility of aspiration pneumonia [18]. Keeping the head of the patient's bed raised between 30°~45° degrees and positioning the support under the knee with elevation to 10°~20° in the semi-recumbent position group and the combined group significantly move the diaphragm downward, expand cheat capacity, subsequently improved oxygenation and ventilation and facilitated weaning [19]. This operation reduced ventilator days to 8.64±3.28 days (semi-recumbent position group) and 7.22±3.73 days (combined group) from 10.21±4.75 days (control group). It also promoted food to get through pylorus and advance to small intestine and reduced the gastric retention; effectively prevent the occurrence of reflux and aspiration of gastric contents. Additionally, semi-recumbent position can widen patients' sight, in favor of communication with them, improve patients' feeling of comfort, relieve their loneliness and fear state, which is conducive to the obedience to the doctor's advice and confidence to treatment [20].

In our present study, we found that at ventilator days 4~6 the incidence of VAP is not significantly different in the groups of semi-recumbent position and combination compared with the that in the control group, however, 8 days after initiation of mechanical ventilation, the advantage of semi-recumbent position and subglottic secretion drainage in reducing VAP began to demonstrate. According to our study,

the average days of mechanical ventilation ranged from 7 to 9, it indicated that the combined treatment of semi-recumbent position and subglottic secretion drainage in reducing VAP has its superiority within 48 h after weaning. Combined treatment can reduce the length of ICU stay, medical cost and healthcare burden, but has no influence on mortality once the occurrence of VAP.

Ventilator associated pneumonia is associated with increased duration of mechanical ventilation, length of hospital burden for the healthcare system and suffering and mortality of patients. Combination treatment with semi-recumbent position and subglottic secretion drainage can effectively prevent the VAP pathogenesis, improve the chance for saving critical patients, it is important for the development of critical medical.

Conclusion

According to our investigation, we found that semi-supine position or SSD could reduce the incidence of VAP 6 days after mechanical ventilation. The superiority of combination of semi-supine position or SSD began to emerge at 8 days after mechanical ventilation. However, neither semi-supine position nor SSD could reduce the mortality of VAP. Combined treatment could efficiently reduce the length of ICU stay, medical cost and healthcare burden, but has no influence on mortality once the occurrence of VAP.

Relevance to clinical practice

Semi-supine position combined with SSD is the both medical choice and the nursing mean on the patients of mechanical ventilation. It can reduce the incidence of VAP despite no influence on the mortality once the occurrence of VAP. Combination treatment of semi-supine position and SSD is considered to be particularly effective and most economical therapeutic method of reducing the incidence of VAP in ICU.

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Disclosure of conflict of interest

None.

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