Nosocomial bacterial pneumonia is the leading cause of death among all hospital-acquired infections. 

Ventilator-associated pneumonia (VAP) specifically refers to nosocomial pneumonia that develops in a mechanically ventilated patient and that is not present at the time of airway intubation. VAP has been a major threat to patients receiving mechanical ventilation and increases their mortality and hospital costs. 

These investigations suggested that frequent circuit changes do not decrease and, even worse, might increase the incidence of VAP. Changing ventilator circuits is not without risk since most patients receiving mechanical ventilation are critically ill. Serious complications such as hypoxemia and arrhythmia may occur with circuit changes.

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Key Words
mechanical ventilators; pneumonia; respiratory therapy; ventilator-associated pneumonia

Background. Frequent ventilator circuit changes are expensive and sometimes unnecessary. Following the worldwide trend to lengthen the intervals for ventilator circuit change from 2 days to 1 week, this study aims to as sure that low rate of ventilator-associated pneumonia (VAP) can be maintained with cost containment.

Methods. Ventilator circuits were routinely changed every 7 days in the study period for 2 years and every 2 days during the historical control period of another 2 years. Pediatric patients (age less than 15 years) were not included. Nosocomial pneumonia was diagnosed by the criteria of the Centers for Disease Control and Prevention (CDC) of the United States (US). VAP was identified by combining and comparing 2 databases from the Respiratory Therapy Department and the Infection Control Unit of our hospital.

Results. In the study group, 225 episodes of pneumonias were observed in 7,068 patients and 87,338 ventilator days. The rate of VAP was 2.58 per 1,000 ventilator days. There were 174 episodes of pneumonia in 6,213 patients and 65,467 ventilator days of the control group. The rate of VAP was 2.66 per 1,000 ventilator days. The difference between both groups was not significant (p = 0.803). Yet, the cost curbed was around 80,000 US dollars per year.

Conclusions. Extending ventilator circuit change intervals from 2 days to 7 days do not increase the risk for VAP, but the cost savings for labor and supply are substantial. [Chin Med J (Taipei) 2001; 64:161-167]

Received: May 25, 2000. Accepted: December 19, 2000.
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although the real incidence is unknown and believed to be under-reported. Frequent change of circuits is also labor-intensive, boring and expensive. Based on previous studies, Centers for Disease Control and Prevention (CDC) of the United States recommended in 1994 not to routinely change more frequently than every 48 hours. This ambiguous guideline placed the responsibility on the hospital to determine the specific circuit-change frequency beyond 48 hours. Since then, several studies have reported the results of prolonging the interval of routine circuit changes from 2 or 3 days to 7 days. The rates of VAP were found to make no significant change with extension of intervals. Fink and co-workers even reported that 7-day interval had lower risks for VAP than 2-day interval.

Following this worldwide trend, our hospital has extended the interval from every 2 days to every 7 days since November 1995. By comparing the incidence of VAP before and after this policy change in a 2-year period, this prospective historical control study aims to assure that the quality of patient care can be adequately maintained.

**Methods**

**Patients**

The control group of this study consisted of all patients above 14 years of age in our hospital receiving conventional mechanical ventilation for more than 24 hours between November 1991 and October 1993. During that 2-year period, ventilator circuits were changed every 2 days. The interval of circuit changes was extended to 7 days from November 1995. All patients above 14 years of age with conventional mechanical ventilation for more than 24 hours from November 1995 to October 1997 were thus included as study group. Patients with non-invasive ventilation or high frequency ventilation were excluded. Neonatal and pediatric patients were also excluded due to the concern of VAP from the pediatricians of our hospital. The study protocol was approved by the Infection Control Committee of our hospital.

**Equipments**

The ventilators used in both study and control groups included Puritan-Bennett MAI and 7200 (Carlsbad, California), Siemens Servo 900C (Solna, Sweden), Bird 6400 and 8400 (Bird Products Corporation, Palm Springs, California), Bear 1000 (Bear Medical System, Riverside, California) and PLV-100 (LifeCare, Boulder, Colorado). Unheated reusable ventilator circuits (Bird) with Y connectors were used. Water traps (Bird) were placed midway between the ventilator and the patients on both the inspiratory and expiratory limbs to collect tubing condensate. Condensate was evacuated aseptically on a regular basis without opening the circuit or interrupting mechanical ventilation. For patients using Puritan-Bennett MAI and 7200 series ventilators, humidification was provided with heated cascade humidifiers (Puritan-Bennett). Other ventilator circuits were equipped with wick-type closed-fasted humidifiers (Bird Humidifier Model 3000). All ventilator circuits in cluding gas delivery tubing, water traps and associated adapters were disinfected by using small-volume nebulizers. Metered-dose inhalers with a collapsible chamber (Aerovent, Monaghan Medical, Inc, Plattsburgh, New York) was occasionally used for the delivery of inhaled steroids.

**Circuit changes**

Ventilator circuits including gas delivery tubing, humidifiers, water traps and associated adapters were changed between patients and at 2-day or 7-day intervals, which were executed by respiratory therapists. In addition, ventilator circuit could be changed, in part or as a whole, at the discretion of individual care providers (physicians, nurses and respiratory therapists), secondarily to a mechanical failure of the ventilator circuit (such as air leak) or visible soil.
Identification of ventilator-associated pneumonia

Nosocomial pneumonia was surveyed by the Infection Control Unit of our hospital supervised by an infection doctor. By CDC criteria, pneumonia was defined as follows: (1) rales or dullness to percussion on physical examination of chest and either new onset of purulent sputum or change in character of sputum, or organisms isolated from blood culture, and/or isolation of pathogen from transtracheal aspirate, bronchoalveolar lavage (BAL), or bronchchoscopy, or biopsy; or (2) chest radiographs showing new or progressive infiltrate, consolidation, cavitation, or pleural effusion and any of the following: new onset of purulent sputum; or organisms isolated from transtracheal aspirate, bronchial brushing or biopsy; isolation of virus or detection of viral antigen in respiratory secretions; diagnostic single antibody titer (IgM) or fourfold increase in paired serum samples (IgG) for pathogen; histopathologic evidence of pneumonia. Chest radiographs were evaluated by a radiologist.

For infection surveillance, data relevant to nosocomial pneumonia were collected and recorded in the Infection Control Unit of our hospital. These data contained all in patients with nosocomial pneumonia whether they were receiving mechanical ventilation or not.

Data of ventilator utilization, collected by Respiratory Therapy Department, included date of initiation and termination of mechanical ventilation. Patients receiving mechanical ventilation less than 24 hours were kicked out of the database before further analysis. Then VAP was identified by combining both data bases from the Infection Control Unit and the Department of Respiratory Therapy. Pneumonia occurring within 24 hours after initiation of mechanical ventilation and 24 hours after termination of mechanical ventilation was not considered ventilator-associated.

Statistical analysis

The proportions of patients with ventilator-associated pneumonia in both study and control groups were calculated as the number of cases per 1,000 ventilator days. Differences between groups were determined using two sample test for incidence-density measures. p values of 0.05 or less were considered statistically significant.

Results

Rates of ventilator-associated pneumonia

In the study group, in which the interval of circuit changes was 7 days, there were 225 pneumonias among 7,068 patients and 87,338 ventilator days throughout the period of 2 years. The rate of VAP was 2.58 per 1,000 ventilator days. There were 174 pneumonias among 6,213 patients and 65,467 ventilator days in the control group in which ventilator circuits were changed every other day. The rate of VAP was 2.66 per 1,000 ventilator days. The difference between the groups was not significant (p = 0.803).

Cost analysis

The average amount of ventilator-time in use at our hospital during the study period, apart from those for pediatric use, was 164 per day. If their circuits were changed every other day, 82 circuits would have to be changed per day. Since the interval of circuit changes was extended to 7 days, only 24 circuits were changed.

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<th>Table 1. Characteristics and rates of ventilator-associated pneumonia (VAP) of the patients according to group</th>
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<td>Characteristics</td>
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<td>Circuit change interval</td>
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p value of VAP rates between two groups is 0.803.
per day. Thus 58 circuit changes per day were saved. It took respiratory therapist a 14 minutes to change a ventilator circuit. The salary for respiratory therapist was 6.4 New Taiwan (NT) dollars per minute. The yearly cost thus being saved was approximately 1.9 million NT dollars (6.4 × 14 × 58 × 365). Each reusable circuit costs 3300 NT dollars. Then, 191,400 NT dollars would be saved per year (3300 × 58 × 58) if we assumed that each circuit could last for one year after repeated use and disinfection. The cost of disinfection for each ventilator circuit including both labor and materials was 24 NT dollars and thus 400,000 (24 × 58 × 365) NT dollars were saved per year. In sum, the total cost reduction was approximately 2.5 million NT dollars if we assumed that each circuit could last for one year after repeated use and disinfection. The cost of disinfection for each ventilator circuit in our study was 24 NT dollars and thus 400,000 (24 × 58 × 365) NT dollars were saved per year.

**Discussion**

The findings of this study suggest that the interval of circuit changes can be safely extended from 2 days to 7 days without significant increase in rates of VAP. This result agrees with most of similar studies prolonging the circuit change interval beyond 2 days. The remarkable sample size of more than 20,000 ventilator days extending circuit change interval from 24 hours to 7 days found similar results to ours. In their study, however, only a period of 6 months before and after the interval extension was covered by either control or study group. Doubt can be raised that the difference in season between their control and study groups might have some influence on the incidence of VAP to confound the conclusion drawn by their study. This is supported by a famous study done by Craven and colleagues, in which the rate of VAP was significantly higher in fall and winter with an odd ratio as high as 2.1. In contrast, our study covering a span as long as 2 years of either study or control group should be of great value to compensate the design defect of Hess’ study.

In addition to reducing possible complications from circuit changes, the cost savings of 2.5 million NT dollars per year evidenced in this study are quite

![Fig. 1. Comparison of the annualized costs between the control and the study groups. One-week in interval of circuit changes, compared with 2-day in interval, can substantially saved the cost (1.0 vs. 3.5 million NT Dollars). The major savings relate to the labor costs of respiratory therapists.](image-url)
note worthy. The major cost re duc tion (1.9 mil lion NT dol lars) was man power-related, which was not nec es sarily in dic a tive of de creas ing the num ber of staff. How ever, the ther a pists could be re lieved, at least in part, from the bor ing rou tines of cir cuit changes to other more con struc tive and cre ative jobs. Be cause of the dif fi culty in quan ti fi ca tion, the pres ent study did not take this ef fect into con sid er ation of cost ef fec tive ness.

One of the lim i ta tions of this study is the di ag no sis of pneu mo nia. In the crit i cally ill pa tients re ceiv ing me chan i cal ven ti la tion, it is very dif fi cult to es tab lish the di ag no sis of pneu mo nia due to con tam i na tion of the air ways af ter endotracheal intubation as well as the fre quent pres ence of co ex isting prob lems such as car dio gen ic pul mo nary edema and atelec tasis. Se ver al stud ies val i date the use of quan ti ta tive cul tures of pro tected brush spec i men to di ag noise VAP. Dreyfuss and co work ers used this in va sive tech nique for the di ag no sis of VAP in their study and found no sig ni fic ant dif fer ence in the VAP rate whether the ven ti la tor cir cuits were changed ev ery 48 hours or not. How ever, their sam ple size (N = 73) was so much re strained by the com plex ity of the in va sive di ag nos tic method for VAP that any con clu sion of no dif fer ence be tween the groups will be con sid ered hasty. Be sides, the ac cu racy of this tech nique may be com pro mised by the in flu ence of an ti bi ot ics on the cul ture re sults and re mains to be dou bled by other in vest i gators.

In this light, the use of clin i cal cri te ria in this study to di ag nose VAP is much more prac ti cal. Al though the com plex ity of the in va sive di ag nos tic method for VAP that any con clu sion of no dif fer ence be tween the groups will be con sid ered hasty. Be sides, the ac cu racy of this tech nique may be com pro mised by the in flu ence of an ti bi ot ics on the cul ture re sults and re mains to be dou bled by other in vest i gators.

The rate of VAP in this study seems to be lower than find ings from pre vi ous stud ies. The ac tu al rea sons are un known, al though the com plex ity and am bi gu ity in the di ag nos tic method for VAP may well ex plain such dif fer ence. More over, we do not think this dif fer ence would have sig ni fic ant im pact on the risk of VAP and the cost sav ings for la bor and sup ply are sub stan tial.

In the inv es ti ga tion by Fink and col leagues, the VAP rate in creased from 3.34 to 6.28 per 1,000 ven ti la tor-days after the in ter val in creased from 7 days to 30 days. This dif fer ence was quite re mark able al though not stat is ti cally sig nifi cant. There fore, we agree to the con clu sion of a re view ar ti cle writ ten by Stamm in 1998 that ven ti la tor cir cuits should be changed ev ery 7 days and data are in ad e quate to sup port recom men da tion of less fre quent changes or elim ina tion of the prac tice of rou tine changes.

We con clude that extend ing ven ti la tor cir cuit change in ter val from 2 days to 7 days has no im pact on the risk of VAP and the cost sav ings for la bor and sup ply are sub stan tial.

Acknowledgments

The au thors would like to thank all the staff of the Respiratory Therapy Depart ment and the In fec tion Con trol Unit of Tai pei Vet erans Gen eral Hos pital for their ap pre cia ble help with data col lec tion for this study.

References


