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Removal of oral secretion prior to position change can reduce the incidence of ventilator-associated pneumonia for adult ICU patients: a clinical controlled trial study

Yann-Fen C Chao, Yin-Yin Chen, Kai-Wei Katherine Wang, Ru-Pin Lee and Hweifar Tsai

Aim. The purpose of this study was to explore the effect of oral secretion on aspiration and reducing ventilator-associated pneumonia.

Background. Ventilator-associated pneumonia is a serious hospital-acquired infection with reported incidence rate of 12·2% and mortality rate of 29·3%. Oral secretion is purported as a media which brings the oropharyngeal pathogens down to the respiratory track.

Methods. Two-group comparison study design was adopted. Subjects were recruited from an adult general intensive care unit of a medical centre in Taipei city. Patients in the study group received suction of oral secretion before each positional care, in contrast with patients in the control group who received routine care.

Results. Ventilator-associated pneumonia was found in 24 of 159 (15·1%) patients in the control group and in five of 102 (4·9%) patients in the study group with a reduction of risk ratio of 0·32 (95% CI 0·11–0·92). Eight of the 24 ventilator-associated pneumonia patients died in the control group; however, none of those ventilator-associated pneumonia patients died in the study group. The increased chance of survival was 1·50 (95% CI 1·13–1·99). The length of stay in ICU and duration of mechanical ventilation were reduced in the study group. In consideration of cost, the cost of tubes used to remove oral secretion is much less than the one used to do continuous subglottal suction.

Conclusion. Removal of oral secretion is effective in reducing the incidence of ventilator-associated pneumonia with minimum cost intervention.

Relevance to Clinical Practice. This study provides evidence that removal of oral secretion prior to position change is cost effective to reduce the incidence of ventilator-associated pneumonia. As such intervention is an easy task, routine removal of oral secretion is recommended as the standard of daily nursing care of patients on ventilator.

Key words: aspiration secretion, intensive care unit, nurses, nursing, ventilator-associated pneumonia

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Introduction

Nosocomial pneumonia is a leading cause of death from hospital-acquired infection. Ventilator-associated pneumonia (VAP) refers to nosocomial bacterial pneumonia that has developed in patients who are receiving mechanical ventilation (Kollef 1999). The recent reported incidence rate is 11·0% with mortality rate of 29·3% (Kollef *et al.* 2005). More than half of the patients in intensive care units (ICUs) are on ventilator. They experience the risk of developing VAP. Therefore, healthcare profession must identify the most effective way to control the development and progress of VAP in patients.

Authors: *Yann-Fen C Chao*, RN, PhD, Professor, College of Nursing, Taipei Medical University, Taipei, Taiwan; *Yin-Yin Chen,* RN, DrPH, Associate Head Nurse, Veteran General Hospital, Taipei, Taiwan; *Kai-Wei Katherine Wang,* RN, PhD, Assistant Professor, School of Nursing, National Yang-Ming University, Taipei, Taiwan; *Ru-Pin Lee,* RN, PhD, Associate Professor, College of Medicine, Tzu-Chi University, Hualien, Taiwan; *Hweifar Tsai*, RN, MSN, Staff Nurse, Veteran General Hospital, Taipei, Taiwan

Correspondence: Yann-Fen C Chao, Professor, College of Nursing, Taipei Medical University, 250 Wu-sin St., Taipei, Taiwan. Telephone: +886 2 23777417.

E-mail: yfchao@tmu.edu.tw

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The literature reports that the risk factors for VAP include lack of oral care, reduced level of consciousness, body position, a nasogastric tube, vomiting, swallow disorder, endotracheal tube insertion with the use of ventilator, humidifier contamination, use of antacid and/or H_2 blocker medication and the care providers' violation of infection control protocol (Kollef 1999, Chastre & Fagon 2002). Further findings indicated that medication nebulizer inserted into the inspiratory phase tube of the mechanical ventilator circuit (aerosol therapy) may inadvertently be responsible for bacterial aerosol after a single use (Craven *et al.* 1984). There are also several associated factors such as neurosurgery and/or neurological injury, chest and upper abdominal surgery, poor health status, history of lung disease, diabetes mellitus and length of hospitalisation (Chastre & Fagon 2002).

There are pharmacological and non-pharmaocological methods in the control of an infection. The pharmacological methods include prevention of stress ulcer, mouth swash (rinse) with chlorhexidine solution (Munro & Grap 2004), administering γ-globin and vaccines (Kollef 1999). The non-pharmacological methods refer to using oral instead of nasal route for intubation (Bert & Lambert-Zechovsky 1996), comprehensive oral care (Garcia 2005), continuous subglottal suctioning (Smulders *et al.* 2002), hand washing (Nagata *et al.* 2002), preventing stomach overload, bed elevation (Torres *et al.* 1992) and use of continuous lateral rotation and vibration therapy(Ahrens *et al.* 2004, Hess 2005).

Infection control can begin with defeating off the pathogen, cutting off the transmit route and strengthening the host defence. Comprehensive oral care is the preventive strategy focus on reducing bacterial flora in the oral cavity. The intervention of continuous subglottal suction is working on removal of the pooled saliva above the endotracheal cuff. As the abnormal salivary flow may place patients at risk of overgrowth of organism in the oropharynx such as *Staphylococcus aureus* and *Pseudomonas aeuroginosa*, we theorised that oral secretion is a median which can serve as a carrier of the oropharyngeal pathogen down to the respiratory track. We postulate that removal of oral secretion before changing a patient's position can prevent or reduce the movement of oropharyngeal pathogen down to the respiratory track leading to pulmonary infection. This clinical trial was to evaluate the effect of removal of oral secretion before changing patient's position on reducing the incidence of VAP, length of ICU stay and mortality.

Material and methods

This was a two-group comparison study. We recruited subjects from a 48-bed adult general ICU of a medical centre in Taipei city. The year admission number of this ICU was 1860 with an on-vent rate of 73·4% (person day on ventilator divided by person day in the setting) during the study period. Patients admitted to this unit were based on bed availability and bed assignment was random. The inclusive criteria for the study were patients who were: (1) 18 years of age or older; and (2) on a ventilator for more than 24 hours. Patients who developed pneumonia before intubation or within 48 hours after intubation were excluded. The exclusion was made when a positive sputum culture was obtained from a sample taken before or within 48 hour of intubation. We recruited patients (n = 646) who were admitted to the unit in the first four months (September to December) of the study as the control group. The subjects in the control group were cared for by routine, the patient's oral secretion was removed after each completion of endotracheal suction. Then, we arranged a two-month interval to prepare nurses in this unit familiar with the study protocol. The removal of oral secretion protocol was as follows: before each change of patient position, a saliva eject tube was inserted into patient's month to suction the secretions away by a pressure of 60–80 mmHg. The suction was continued for 10 seconds and the secretion was collected into a transparent container for observation. In the following four months (March to June), we recruited patients (n = 574) for the study group. Compared with the control subjects, oral secretion was suctioned before each patient turn. The data collection period of four months in a series in each phase was determined for attaining a more stable data than one month.

Ventilator-associated pneumonia (VAP) is defined as patients receiving mechanical ventilation for at least 24 hours with a first positive bacterial respiratory culture findings after ventilator commencing date (Kollef *et al.* 2005). When a pneumonia sign or symptom was present, sputum was aspirated by suction technique and collected in a sterile container. The sample was kept at room temperature and was sent to the laboratory within eight hours. In the bacteriology laboratory of the teaching hospital, the sample of sputum was placed in a container with substances that promote the growth of bacteria or fungi. If no bacteria or fungi grow, the culture is negative. If organisms that can cause infection (pathogenic organisms) grow, the culture is positive. Using the disk diffusion method, the bacteriology laboratory also carried out antibiotic susceptibility tests on sputum cultures (National Committee for Clinical Laboratory Standards. 1993).

The study was conducted under the approval of the hospital ethics committee. A research nurse who was the staff of the unit conducted data collection. If the secretions appeared to look like a mixture of saliva, sputum

and emesis, no further analysis on it was attempted. All of the subjects were followed from the day they enrolled into the study to the day they left the ICU to evaluate the numbers of their ICU stay, the number of days on ventilator and mortality rates.

Data were processed by SPSS/PC 12.0 version (SPSS Inc., Chicago, IL, USA). The major statistical procedures applied were descriptive statistics, *t*-test, chi-squared, one-way ANOVA and logistic regression. If any data did not meet the criteria of normal distribution, a non-parametric statistical procedure was applied. A value of $p < 0{\cdot}05$ was considered statistically significant.

Results

Characteristics of the subjects

There were 159 control subjects and 102 experimental subjects. Subjects' information listed in Table 1 (gender, age, history of chronic obstructive lung disease (COPD) and DM, the usage of antibiotic, antacids, aerosol therapy, APACHE II scores, Glasgow Coma Scale score, serum albumin levels, reintubation status, ICU days, ventilator days and mortality rates). The statistical results showed that there were significant differences in the distributions of having a surgery, COPD and DM history and usage of antacids between two groups ($p < 0{\cdot}05$). These variables were examined by logistic regression for their impact on developing VAP (Table 2). The results indicated that their impact on the development of VAP were not significant as the 95% CI of the odds ratio included 1 and $p > 0{\cdot}05$. The incidence rate of early VAP was 15·1% (24/159) in the control group and 4·9% (5/102) in the study group. The relative risk of VAP in the study group was 0·32 of the control group (95% CI 0·11–0·92, $p < 0{\cdot}05$).

Table 1 Demographic and health-related information of the subjects

Background information	Study group (n = 102)	Control group (n = 159)		
	N (%)	*N* (%)	χ^2/t	*p*
Gender				
Male	70 (68·4)	121 (76·1)	1·75	0·18
Female	32 (31·4)	38 (23·9)		
Surgery				
No	47 (46·1)	50 (31·4)	5·66	0·01
Yes	55 (53·9)	109 (68·6)		
COPD				
Yes	8 (7·8)	28 (17·6)	5·33	0·02
No	94 (92·2)	131 (82·4)		
DM				
Yes	41 (40·2)	89 (56·0)	6·21	0·01
No	61 (59·8)	70 (44·0)		
Antibiotics				
Yes	101 (99·0)	158 (99·4)	0·09	0·75
No	1 (1·0)	1 (0·6)		
Antacid				
Yes	58 (56·9)	114 (71·7)	6·03	0·01
No	44 (43·1)	45 (28·3)		
Aerosol therapy				
Yes	19 (18·6)	41 (25·8)	1·83	0·17
No	83 (81·4)	118 (74·2)		
NG feeding				
Yes	74 (72·5)	114 (71·7)	0·02	0·88
No	28 (27·5)	45 (28·3)		
Reintubation				
Yes	10 (9·8)	14 (8·8)	0·07	0·78
No	92 (90·2)	145 (91·2)		
	Mean ± SD	Mean ± SD		
Age	71·73 ± 14· 32	67·94 ± 16·47	−1·90	0·14
APACHE score	24·01 ± 7·33	25·09 ± 6·48	1·24	0·28
GCS	11·09 ± 4·18	7·03 ± 4·09	−7·75	0·10
Albumin	2·67 ± 0·54	2·59 ± 0·52	−1·19	0·88
Outcomes				
VAP				
Yes	5 (4·9)	24 (15·1)	7·24	< 0·001
No	97 (95·1)	135 (84·9)		
Death				
Yes	19 (18·6)	29 (18·2)	0·006	0·93
No	83 (81·4)	130 (81·8)		
Days on vent.	15·95 ± 13·47	19·30 ± 14·76	1·85	0·026
Days in ICU	16·38 ± 11·60	19·77 ± 14·56	1·98	0·004

The risk factors of VAP in the control group

The demographic and health-related data of the 24 subjects who developed VAP in the control group were compared with the 135 subjects who did not develop VAP. There were no significant differences in gender, age, COPD and DM history, the usage of antibiotic and antacids, APACHE II scores, Glasgow Coma Scale (GCS) score, serum albumin levels. There were significant differences in the use of aerosol therapy and reintubation. The use of aerosol therapy occurred in 12 of the 24 (50·0%) patients in the VAP group and 29 of 135 (21·5%) patients in the non-VAP group, with the relative risk of developing VAP of 3·65 (95% CI 1·49–8·90, $p < 0{\cdot}05$). Five of those 24 (20·8%) patients in the VAP group experienced reintubation, while only nine of those 135 (6·7%) in the non-VAP group were reintubated, with the relative risk of developing VAP of 3·68 (95% CI 1·12–12·17, $p < 0{\cdot}05$).

During the ICU stay, eight (33·3%) VAP subjects and 21 (15·6%) non-VAP subjects died in the control group. The development of VAP increased the relative risk of death by 2·71 times (95% CI 1·03–7·15, $p < 0{\cdot}05$). The VAP subjects

Table 2 Logistic regression of ventilator-associated pneumonia risk factors that demonstrated significant difference in distribution between the two groups

	β	*p*	95% CI for exp(β) Lower	Upper
Surgery	0·22	0·60	0·56	2·75
COPD	0·85	0·26	0·53	10·32
DM	−0·07	0·86	0·43	2·03
Antacids	0·00	1·00	0·44	2·28

also significantly spent more days on ventilators and their stay in ICU were longer than non-VAP subjects ($p < 0·05$) (Table 3).

The risk factors of VAP in the study group

In the study group, five of the 102 (4·9%) subjects developed VAP. The demographic and health-related data of VAP and non-VAP subjects in the study group were compared and listed in Table 4. No significant differences were found. In addition, no significant differences in mortality rate, ventilator days and length of ICU stay between VAP and non-VAP subjects within the study group were found. These results are different from the findings seen with the control group.

Difference in risk factors and pathogens of VAP between the two groups

The demographic and health-related factors of VAP subjects of the two groups were compared and the results are listed in Table 5. There were no significant differences in gender, age, COPD and DM history, usage of antibiotic, antacids, aerosol therapy and reintubation rates ($p > 0·05$). None of the VAP subjects in the study group died, whereas eight deaths in the control group had VAP. Chance of survival for VAP subjects in the study group was 1·50 times (95% CI 1·13–1·99) greater than the ones in the control group. Days on ventilator and number of days in ICU were significantly less in the study group than in the control group (15·4 SD 5·5 vs. 24·4 SD 18·3; 15·8 SD 5·3 vs. 24·6 SD 18·5, respectively, $p < 0·05$).

The VAP pathogens identified from sputum culture for the two groups are listed in Table 6. The reported bacteria associated with early VAP included *Haemophilus influenzae*, *Enterobacter* spp., *Klebsiecla* spp., *Escherichia coli*, *Serratia* spp., *Proteus* spp., *Stenotrophomonas* and methicillin- or oxacillin-sensitive staphylococcus (Cook *et al.* 1998, Kollef 1999, American Thoracic Society 2005). The pathogens found in the control group were consistent with findings in the literature; however, several pathogens found in the study group were much lower than in the control group.

Table 3 Demographic and health-related information of non-VAP and VAP subjects in the control group

Background information	Non-VAP (*n* = 135) *N* (%)	VAP (*n* = 24) *N* (%)	χ^2/t	*p*
Gender				
Male	102 (75·6)	19 (79·2)	0·15	0·69
Female	33 (24·4)	5 (20·8)		
Surgery				
No	41 (30·4)	9 (37·5)	0·46	0·49
Yes	94 (69·6)	15 (62·5)		
COPD				
Yes	26 (19·3)	2 (8·3)	19·4	0·16
No	109 (80·7)	22 (91·7)		
DM				
Yes	77 (57·0)	12 (50·0)	0·40	0·65
No	58 (43·0)	12 (50·0)		
Antibiotics				
Yes	134 (99·3)	24 (100)	0·32	0·56
No	1 (0·7)	0 (0)		
Antacid				
Yes	97 (71·9)	17 (70·8)	0·01	0·91
No	38 (28·1)	7 (29·2)		
Aerosal therapy*				
Yes	29 (21·5)	12 (50)	7·77	0·005
No	106 (78·5)	12 (50)		
NG feeding				
Yes	95 (70·4)	19 (79·2)	0·82	0·37
No	40 (29·6)	5 (20·8)		
Reintubation†				
Yes	9 (6·7)	5 (20·8)	4·07	0·004
No	126 (93·3)	19 (79·2)		
	Mean ± SD	Mean ± SD		
Age	67·6 ± 15·8	69·5 ± 19·9	−0·52	0·16
APACHE score	25·2 ± 6·4	24·2 ± 6·5	0·65	0·96
GCS	6·9 ± 4·1	7·2 ± 3·8	−0·29	0·47
Albumin	2·5 ± 0·5	2·6 ± 0·6	−0·27	0·25
Outcomes				
Death‡				
Yes	21 (15·6)	8 (33·3)	3·79	0·05
No	114 (84·4)	16 (66·7)		
Days on Vent.	18·3 ± 13·9	24·4 ± 18·3	−1·85	0·007
Days in ICU	18·9 ± 13·6	24·6 ± 18·5	−1·79	0·004

*Odd ratio for VAP: 3·65, 95% CI 1·49–8·90.
†Odd ratio for VAP: 3·68, 95% CI 1·12–12·17.
‡Odd ratio for death: 2·71, 95% CI 1·03–7·15.

Discussion

The control group who did not receive oral suctioning prior to position change demonstrated a VAP incidence rate of

Table 4 Demographic and health-related information of non-VAP and VAP subjects in the study group

Background information	Non-VAP (n = 97)	VAP (n = 5)		
	N (%)	N (%)	χ^2/t	p
Gender				
Male	66 (68·0)	4 (80)	0·34	0·55
Female	31 (32·0)	1 (20)		
Surgery				
No	44 (45·4)	3 (60)	0·41	0·52
Yes	53 (54·6)	2 (40)		
COPD				
Yes	8 (8·2)	5 (100)	0·83	0·36
No	89 (91·8)	0 (0)		
DM				
Yes	38 (39·2)	3 (60)	0·83	0·36
No	59 (60·8)	2 (40)		
Antibiotics				
Yes	96 (99)	5 (100)	0·10	0·75
No	1 (1)	0 (0)		
Antacids				
Yes	56 (57·7)	2 (40)	0·60	0·43
No	41 (42·3)	3 (60)		
Aerosol therapy				
Yes	17 (17·5)	2 (40)	1·30	0·25
No	80 (82·5)	3 (60)		
NG feeding				
Yes	69 (72·1)	5 (100)	3·31	0·07
No	28 (27·9)	0 (0)		
Reintubation				
Yes	9 (9·3)	1 (20)	0·49	0·48
No	88 (90·7)	4 (80)		
	Mean ± SD	Mean ± SD		
Age	72·0 ± 13·9	65·0 ± 21·2	1·07	0·17
APACHE II score	23·7 ± 7·1	29·2 ± 9·8	−1·63	0·36
GCS	11·1 ± 4·1	9·8 ± 5·0	0·70	0·60
Albumin	2·6 ± 0·5	2·6 ± 0·5	0·08	0·91
Outcomes				
Death				
Yes	19 (19·6)	0 (0)	2·12	0·14
No	78 (80·4)	5 (100)		
Days on vent.	15·9 ± 13·7	15·4 ± 5·5	0·09	0·28
Days in ICU	16·4 ± 11·8	15·8 ± 5·3	0·11	0·29

Table 5 Comparison of demographic and health-related information of VAP subjects from both groups

	Study group (n = 5)	Control group (n = 24)		
	N (%)	N (%)	χ^2/t	p
Gender				
Male	4 (80)	19 (79·2)	0·002	0·97
Female	1 (20)	5 (20·8)		
COPD				
Yes	5 (100)	2 (8·3)	0·78	0·37
No	0 (0)	22 (91·7)		
DM				
Yes	3 (60)	12 (50·0)	0·16	0·68
No	2 (40)	12 (50·0)		
Antibiotics				
Yes	5 (100)	24 (100)		
No	0 (0)	0 (0)		
Antacids				
Yes	2 (40)	17 (70·8)	1·65	0·19
No	3 (60)	7 (29·2)		
Aerosol therapy				
Yes	2 (40)	12 (50·0)	0·16	0·68
No	3 (60)	12 (50·0)		
NG feeding				
Yes	5 (100)	19 (79·2)	2·10	0·15
No	0 (0)	5 (20·8)		
Reintubation				
Yes	1 (20)	5 (20·8)	0·002	0·967
No	4 (80)	19 (79·2)		
	Mean ± SD	Mean ± SD		
Age	65·0 ± 21·2	69·5 ± 19·9	0·46	0·89
APACHE II score	29·2 ± 9·8	24·2 ± 6·5	−1·13	0·52
GCS	9·8 ± 5·0	7·2 ± 3·8	−0·61	0·09
Albumin	2·6 ± 0·5	2·6 ± 0·6	−0·11	0·62
Outcomes				
Death				
Yes	0 (0)	8 (33·3)	3·60	0·05
No	5 (100)	16 (66·7)		
Days on vent.	15·4 ± 5·5	24·4 ± 18·3	1·07	0·005
Days in ICU	15·8 ± 5·3	24·6 ± 18·5	1·04	0·006

15·1% (24/159) which is within the range of 8–28% as reported by Chastre and Fagon (2002) in their systematic review paper. This finding is also greater than Kollef *et al*'s (2005) 11·0% from a large US database on healthcare-associated pneumonia. The incidence rate of VAP was 4·9% (5/102) in the study group. The reduced rate in the study group suggests that removing oral secretion before position change was effective in preventing the development of VAP in ICU. Although subjects in the two groups had some significant differences in background characteristics which were reported as risk factors for VAP in the literature (Table 1); they were not significant risk factors for VAP in this study as examined by logistic regression (Table 2). Their risks of developing VAP might be much less than the risks of using aerosal therapy; thus, they were not selected as significant factors by the multivariate analysis procedures in this study.

In the study setting, the aerosol therapy was ordered to liquefy the copious sputum to ease removal. The percentage of using aerosol therapy in VAP subjects was significantly higher than in non-VAP subjects of the control group (Table 3). Gilmour *et al*. (1995) and Thompson (1996) also reported a high percentage of using aerosol therapy in VAP

Table 6 Pathogens of VAP in the control and experimental groups

Pathogens	Control group	Study group
Acinetobacter	7	1
Pseudomonas	5	1
Stenotrophomonas	3	0
Escherichia coli	3	0
Enterococcus	3	0
Klebsiella pneumonia	1	2
Staphylococcus	1	1
Enterobacter	1	0

subjects in their studies and suggested that the use of aerosol therapy is a risk factor for the development of VAP; however, the use of aerosol therapy was not a risk factor for VAP in our study group. As the risk of VAP from aerosol therapy reported in the literature was associated with contamination of the delivery mechanism (Craven *et al.* 1984), the reason why removal of oral secretions may diminish such risk of VAP requires further study. This study has shown the differences in the number of pathogens found in the saliva between the two groups (Table 6) and thus the result confirms the positive effect of reducing the risk of VAP by removal of oral secretion when turning the patient.

Continuous subglottal suction was reported as an effective intervention in reducing the development of VAP (Smulders *et al.* 2002). A meta-analysis study of five clinical trials confirmed the effect of continuous subglottal suctioning on reducing the development of VAP (the reduced relative risk of 0·51, with 95% CI 0·37–0·71, $p < 0·05$) (Dezfulian *et al.* 2005). In this study, the reduced relative risk of oral secretion removal before changing patient's position was 0·32 (95% CI 0·11–0·92, $p < 0·05$). Comparing the cost of the two interventions, continuous subglottal suctioning is an invasive intervention costing $14 more than a traditional endotracheal tube. Removal of oral secretions before turning a patient takes less than 10 seconds and one saliva ejection tube costs less than $0·1. We believe that the proposed intervention from this study is a better choice than continuous subglottal suction in the prevention of VAP in ICU.

Twenty-four of those 159 subjects in the control group developed VAP and eight of them died. The mortality rate was 33·3%. In the study group, five of those 102 subjects developed VAP and with no death. As there was no significant difference in the APACHE scores on admission, both the reduced rates of VAP incidence and mortality might be attributable to the intervention of oral secretion removal prior to position change. The mean of days on ventilator and length of ICU stay of the five VAP subjects in the study group were much less than in the 24 VAP subjects in the control group (Table 5). This study was a two-group comparison conducted in a single site within two consecutive four-month periods. A further study with larger sample size, with concurrent randomised patient allocation and multiple sites may require to confirm the effect of the nursing intervention on VAP management. Nevertheless, removal of oral secretion before turning patient is an easy task with minimal cost; therefore, adopting it as a nursing routine can improve care quality.

In conclusion, this study provides evidence that removal of oral secretion prior to position change is cost effective to reduce the incidence of VAP. Because such intervention is an easy task, routine removal of oral secretion is recommended as the standard of daily nursing care of patients on ventilator.

Contributions

Study design: YFC, RPL, YYC; data analysis: YFC, YYC, HFT, RPL, KWW; manuscript preparation: YFC, KWW.

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