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ORIGINAL ARTICLE

Care Bundle for Ventilator-Associated Pneumonia in a Medical Intensive Care Unit in Northern Taiwan

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Background: Ventilator-associated pneumonia (VAP) occurs in patients requiring mechanical ventilators for more than 48 h. VAP is the most common nosocomial infection and the leading cause of complications and death in intensive care units (ICUs). **Materials and Methods:** Two historical comparison groups of 375 patients who used mechanical ventilators for more than 48 h in the medical ICU (MICU) from December 1, 2011 to May 31, 2012 and December 1, 2013 to May 31, 2014 were enrolled in this study. There were 194 adult patients in the control group that received traditional care, and there were 181 patients in the experimental VAP care bundle group. Our VAP care bundle entailed several preventive strategies including daily assessments of sedation, daily consideration of weaning and extubation by the doctors and respiratory therapists charged with the care of the patients, maintenance of the intra-cuff pressure values at approximately 20-30 cm H_2O, hand hygiene, daily oral hygiene, personal protective equipment for suctioning, the placement of patients in semi-recumbent positions with the head of the bed elevated to at least 30°, aspiration of an endotracheal tube and oral cavity prior to position changes, daily cleaning of the ventilator and suction bottle with sterile distilled water, weekly replacement of the ventilator circuit and heater, sterilization of the circuit by pasteurization, and the use of an independent care room. The data were collected by reviewing the patients' medical records and by retrieving information from the Nosocomial Infection Control Unit of one medical center in Northern Taiwan. **Results:** The incidence of VAP in the VAP care bundle group (0.281 cases per 1000 ventilator days) was significantly lower than that in the control group (0.495 cases per 1000 ventilator days). We estimated that the occurrence of VAP in the MICU increased the medical costs by an average of NT $68317 per patient. **Conclusions:** VAP care bundle is an effective strategy to reduce the incidence of VAP in the MICU and to reduce healthcare costs.

Key words: Ventilator-associated pneumonia, care bundle, medical intensive care unit

INTRODUCTION

Ventilator-associated pneumonia (VAP) is a type of hospital-acquired pneumonia that occurs in patients who are mechanically ventilated for more than 48 h.[1,2] VAP is the leading cause of nosocomial infections in patients in intensive care units (ICUs).[1-4] The pathogenesis of VAP originates from microbial pathogens that are aspirated through the tracheal tube cuff and into the lower respiratory tract. Subsequent colonization and overwhelming of the host's mechanical, humoral, and cellular defense mechanisms lead to the development of VAP.[1,3,4] VAP can be divided into early-onset VAP, which occurs within 5 days of receiving mechanical ventilation and late-onset VAP, which occurs after more than 5 days of mechanical ventilation. The distinction between early- and late-onset VAP is important because different therapeutic strategies are required based on the differential comorbidities

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and causative factors. Our care bundle designed for early-onset VAP, which is usually caused by micro-aspiration of bacteria colonizing the oropharynx.

Hixson *et al*. believed that ICU nurses can be educated to prevent VAP by decreasing risk factors.[5] A number of strategies initiated by nurses, such as oral care, correct positioning, regular changes of the suction equipment, hand decontamination, and other methods, have been discussed and found to reduce the incidence of VAP.[2,6-8] Assessments of the potential risk factors for VAP are important for ICUs so that effective prevention strategies that reduce the risk factors can be implemented. Emerging evidence has revealed that pathogens are present in the oral and sputum specimens of most patients and these findings support the notion that the micro-aspiration of secretions occurs.[9,10]

Ventilator-associated pneumonia can result in critically ill patients experiencing a higher mortality, morbidity, and prolonged ICU stays. The Institute for Healthcare Improvement (IHI) recommends that all ICUs need to implement a suitable ventilator care bundle to reduce the incidence of VAP to zero.[11] Recently, the implementation of evidence-based care bundle has been proven to produce better outcomes than individual implementations of single procedures; furthermore, no evidence-based care bundle has been shown to be cost-effective from the perspective of hospitals.[7,8] Although varieties of measures and interventions have been proposed to reduce the incidence of VAP,[2,12-16] further research into effective preventive interventions to reduce the incidence of VAP in ICU patients is needed.[4,6,7,17,18] In our hospital, there are no strategies to measure and sustain low incidence of VAP. Hence, we reviewed literatures and discussed to develop suitable components of VAP care bundle for our MICU, including daily evaluation of the exposure due to mechanical ventilation, oral care decontamination using chlorhexidine, regular changing of the suction equipment, hand decontamination and aspiration of an endotracheal tube and oral cavity prior to position changes, use of the semi-recumbent position, and maintenance of sufficient intra-cuff pressure.[4,7,8]

MATERIALS AND METHODS

Study participants

The inclusion criteria for this study were the following: Adult patients (over 18 years old), endotracheal tube placement for more than 48 h, no bedside shaking that limited the use of a high bed angle, and no oral cavity surgeries or treatments. Cases with positive sputum cultures or interpretable chest X-ray examinations taken within 48 h of admission prior to endotracheal tube placement were excluded. There were 194 adult patients in the control group that received traditional care from December 1, 2011 to May 31, 2012, and 181 patients composed the VAP care bundle group from December 1, 2013 to May 31, 2014, in the MICU of one medical center in Northern Taiwan. All registered patients during this follow-up period were included for statistical analysis.

Ventilator-associated pneumonia care bundle and data collection

The preventive strategies of the VAP care bundle created by a panel of two pulmonologists, one infection specialist, four respiratory therapists, four infection control specialists, and 10 trained nurses. Several preventive strategies were implemented in the VAP care bundle, including daily assessments of sedation, daily consideration of weaning and extubation by the doctors and respiratory therapists charged with the care of the patients, the maintenance of intra-cuff pressure values at approximately 20–30 cm H_2O, hand hygiene, daily oral hygiene, the use personal protective equipment during suctioning, the use of a semi-recumbent position with the head of the bed elevated to at least 30°, aspiration of the endotracheal tube and oral cavity prior to changing the patients' positions, daily cleaning of the ventilator and suction bottle with sterile distilled water, weekly replacement of ventilator circuit and heater, sterilization of circuit by pasteurization, and the use of an independent care room. The implementation of the VAP care bundle was started in our MICU from August 1, 2013. Therefore, we retrospectively reviewed the demographic data and analyzed the occurrence of VAP of all MICU patients. The VAP surveillance was performed by a senior pulmonologist and one physician who were blinded to the clinical course interpreted all chest X-ray films independently, a case was categorized as VAP if two or more evaluators agreed on the presence of consolidation, and the numbers of patient-days, device-days, and VAP cases have been collected monthly from the infection control specialists of the Nosocomial Infection Control Unit. The incidence of VAP was calculated as the total number of patients with VAP (after 48 h of mechanical ventilation) divided by the total number of ventilator days, and the result of this division was multiplied by 1000. The medical costs were calculated from the expenses of patients within their stays in the MICU.

Ethical consideration

This historical comparison study was conducted in one medical center in Northern Taiwan from December 1, 2011 to May 31, 2012 and December 1, 2013 to May 31, 2014. This study was approved by the Institutional Review Board of this medical center (IRB 2-103-05-103) and was conducted in accordance with the revised Helsinki Declaration.

Statistical analysis

The retrieval data were input into a Microsoft Excel datasheet. All statistical analyses were computed using SPSS (Version 18.0 for Windows, SPSS, Inc., Chicago, IL, USA). The descriptive results are expressed as mean ± standard deviation for continuous variables and as numbers and percentages for the categorical variables. Differences in the characteristics of the participants were examined with chi-square tests, analysis of variance or analysis of covariance (ANCOVA) analysis as appropriate. $P < 0.05$ was considered to indicate statistical significance.

RESULTS

We compared the experimental (VAP care bundle) and control groups according to the risk factors for VAP with a homogeneity analysis. Our analytic data revealed no significant differences in age, sex, Acute Physiology and Chronic Health Evaluation score, duration of ventilator use, day intubated, histories of chronic obstructive pulmonary disease or diabetes, aerosol or antibiotic therapies, use of a nasogastric tube, or surgery [Tables 1 and 2]. The completion rates of the preventive strategies involved in the VAP care bundle were as follows: 98% for the daily assessments of sedation and daily consideration of weaning and extubation by the doctors and respiratory therapists charged with the care of the patients; 99% for the maintenance of the intra-cuff pressure values at approximately 20-30 cm H_2O; 99% for the hand hygiene and use of personal protective equipment during suctioning; 98% for maintaining the head of the patient at an elevation of at 30°; 98% for the implementation of endotracheal tube and oral secretions aspiration prior to position changes; 99% for the daily cleaning of the ventilator and suction bottle with sterile distilled water; 99% for the daily oral hygiene; 100% for the weekly replacement of the ventilator tube and heater and sterilization of tube by pasteurization; and 100% for the use of an independent care room. The incidence of VAP in the VAP care bundle group (0.281 cases per 1000 ventilator days) was significantly lower than that in the control group (0.495 cases per 1000 ventilator days).

Moreover, cost-effect of VAP care bundle be tested using an ANCOVA model with the length of MICU stay day as a covariate. The result were F (1, 373) = 10.87 and $P = 0.001$ [Table 3]. We estimated that the occurrence of VAP in the MICU increased medical costs by an average of NT $68317 per patient.

DISCUSSION

Previous studies indicated that there have been dramatic successes in improving the quality of patient care by focusing on the implementation of bundles of evidence-based preventive practices.[4,6,12,19,20] The well-known IHI Ventilator Care bundle contains five components: Elevation of the head of the bed, daily "sedation vacations" and assessment of the readiness for extubation, peptic ulcer disease prophylaxis, deep venous thrombosis prophylaxis, and daily oral care with 0.12% chlorhexidine. However, the procedure of subglottic secretion drainage was not included in the preventative strategies of our VAP care bundle due to the use of self-paid programs for subglottic suction equipment and the police of the National Health Insurance (NHI) in Taiwan. Notably, peptic ulcer disease prophylaxis and deep venous thrombosis prophylaxis are not suitable for VAP care bundle in Taiwan due to the regulation of peptic ulcer medications by the NHI and the rarity of the complication of deep venous thrombosis among Chinese patients.[21] Moreover, many studies have demonstrated that semi-recumbent positions over 30° and the removal of oral secretions prior to position changes decrease the incidence of VAP.[10,22,23] A study by Dezfulian indicated that subglottic secretion drainage appears to be effective in the prevention of early-onset VAP among patients who are expected to require >72 h of mechanical ventilation.[24] Most importantly, the development of VAP care bundle should be tailored to the features of specific hospitals and the performances of those hospitals' ICU nurses. In this study, the preventive strategies of the current VAP care bundle were chosen 19 specialists.

Ventilator-associated pneumonia occurs in 9-27% of all intubated patients, and 90% of the episodes of hospital-associated pneumonia occur during the mechanical ventilation

Table 1: Comparisons of the continuous variables between the two groups ($n = 375$)

Item	VAP		Total ($n = 375$) Mean ± SD	F	P
	Care bundle ($n = 181$) Mean ± SD	Control ($n = 194$) Mean ± SD			
Age (year)	72.66±14.57	72.28±14.99	72.88±17.73	0.06	0.807
Duration of ventilator use (day)	11.15±7.18	11.01±7.05	11.95±10.77	0.041	0.839
APACHE II maximum	23.22±8.91	28.32±8.50	9.30±6.78	0.015	0.903

APACHE II maximum = The highest score of acute physiology and chronic health evaluation II score; VAP = Ventilated-associated pneumonia; SD = Standard deviation

Table 2: Comparisons of the categorical variables between the two groups (n = 375)

Item	VAP		Total n (%)	χ^2	P
	Care bundle n (%)	Control n (%)			
Sex					
Male	114 (63.0)	130 (67.0)	244 (65.1)	0.668	0.414
Female	67 (37.0)	64 (33.0)	131 (34.9)		
COPD					
Yes	20 (11.0)	21 (10.8)	41 (10.9)	0.005	0.944
No	161 (89.0)	173 (89.2)	334 (89.1)		
Aerosol therapy					
Yes	50 (27.6)	59 (30.4)	109 (29.1)	0.353	0.552
No	131 (72.4)	135 (69.6)	266 (70.9)		
Antibiotic therapy					
Yes	178 (98.3)	189 (97.4)	367 (97.9)	0.067	0.796
No	3 (1.7)	5 (2.6)	8 (2.1)		
Nasogastric tube use					
Yes	181 (100)	192 (99.0)	373 (99.5)	0.436	0.509
No	0 (0)	2 (1.0)	2 (0.5)		
Diabetes					
Yes	33 (18.2)	39 (20.1)	72 (19.2)	0.211	0.646
No	148 (81.8)	155 (79.9)	303 (80.8)		
Surgery					
Yes	12 (6.6)	14 (7.2)	26 (6.9)	0.050	0.823
No	169 (93.4)	180 (92.8)	349 (93.1)		
Incidence of VAP					
VAP case	1 (0.55)	6 (3.09)	7 (1.87)	4.093	0.000
Device-days	381.42	383.21			

COPD = Chronic obstructive pulmonary disease; VAP = Ventilated-associated pneumonia

Table 3: The cost analysis of MICU stay via the ANCOVA model

Item	VAP*		F	P
	Yes Mean ± SE	No Mean ± SE		
Cost	265163±7702	196846±1034	10.87	0.001

*VAP: The length of MICU stay day as a covariate, F = 1.214, P = 0.271; VAP = Ventilated-associated pneumonia; MICU = Medical intensive care unit; ANCOVA = Analysis of covariance; SE = Standard error

of ICU patients.[1,25] The available data suggest that VAP occurs at rates between 5 and 10 cases per 1000 hospital admissions, and the incidence increases by as much as 6- to 20-fold among mechanically ventilated patients.[26] A trial study in Taiwan demonstrated that the incidence of VAP rate from 15.1% (24/159) to 4.9% (5/102) (P = 0.014) due to the implementation of the practice of removing oral secretions prior to the changes in position.[10] The introduction of VAP care bundle significantly decreased the incidence of VAP (0.281 cases per 1000 ventilator days) compared to the control group (0.495 cases per 1000 ventilator days) in our study. The published literature indicates that healthcare costs for VAP patients are increased by 2.9-6.3-fold in ICUs.[26] In Taiwan, the NHI provides patients in ICUs with constant payments for nursing care (NT $3840/day) and housing (NT $2560/day). The suction tubes were the only item in our VAP care bundle that resulted in extra costs (NT $48/day). Due to the longer hospital stays required by VAP patients, a decrease in MICU costs due to the implementation of the VAP care bundle was approximately NT $68,317.

The mechanisms by which the semi-recumbent position prevents nosocomial pneumonia are not fully understood. Recent studies suggest that patients positioned semi-recumbently at 45° exhibit a significantly lower incidence of VAP than do patients positioned supinely.[23,24] In our VAP care bundle, the use of back-rest elevations of 30° rather than 45° was chosen to avoid the disconnection of the medical pipelines

for the ICU patients. However, a recent meta-analysis provided additional evidence that the typically practice of back-rest elevations of 15-30° is not sufficient to prevent VAP in mechanically ventilated patients.[23] Hence, the functional effect of semi-recumbent positions on the incidence of VAP remains to be further investigated. Additionally, many studies support the notion that the removal of oral secretions prior to position changes can reduce the incidence of VAP among adult ICU patients.[10,22,24] The effects of endotracheal intratube suction remain to be evaluated, particularly in terms of oxygen consumption and damage to the respiratory mucosa.

There are many limitations in this study. First, our study results were limited to the MICU of a single medical center. To expand this VAP care bundle protocol to surgical and pediatric ICUs, we may require modification regarding specific characteristic of these units. Second, the 6-month implementation of the VPA care bundle was hard to avoid unmeasured factors coincided with the interventions, resulting in a decrease in VAP incidence rates in our MICU. Third, our study lacked the compliance rate to each element of VAP care bundle for the evaluation of the care bundle comprehensively.

CONCLUSION

Most of the care measures intended to prevent VAP in intubated patients are performed by nurses in ICUs. The localized VAP care bundles developed based on surveys of the empirical literature are effective in reducing the incidence of VAP in ICUs. We hope to share the experiences of our VAP care bundle in the MICU with other healthcare providers. Finally, the construction of evidence-based nursing science will promote the contribution of nursing to healthcare quality.

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DISCLOSURE

The authors have no financial conflicts of interest.

REFERENCES

1. American Thoracic Society, Infectious Diseases Society of America. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. Am J Respir Crit Care Med 2005;171:388-416.
2. Mietto C, Pinciroli R, Patel N, Berra L. Ventilator associated pneumonia: Evolving definitions and preventive strategies. Respir Care 2013;58:990-1007.
3. Bonten MJ. Healthcare epidemiology: Ventilator-associated pneumonia: Preventing the inevitable. Clin Infect Dis 2011;52:115-21.
4. Lambert ML, Palomar M, Agodi A, Hiesmayr M, Lepape A, Ingenbleek A, *et al.* Prevention of ventilator-associated pneumonia in intensive care units: An international online survey. Antimicrob Resist Infect Control 2013;2:9.
5. Hixson S, Sole ML, King T. Nursing strategies to prevent ventilator-associated pneumonia. AACN Clin Issues 1998;9:76-90.
6. Wilke M, Grube R. Update on management options in the treatment of nosocomial and ventilator assisted pneumonia: Review of actual guidelines and economic aspects of therapy. Infect Drug Resist 2013;7:1-7.
7. Ruffell A, Adamcova L. Ventilator-associated pneumonia: Prevention is better than cure. Nurs Crit Care 2008;13:44-53.
8. Sedwick MB, Lance-Smith M, Reeder SJ, Nardi J. Using evidence-based practice to prevent ventilator-associated pneumonia. Crit Care Nurse 2012;32:41-51.
9. Sole ML, Poalillo FE, Byers JF, Ludy JE. Bacterial growth in secretions and on suctioning equipment of orally intubated patients: A pilot study. Am J Crit Care 2002;11:141-9.
10. Chao YF, Chen YY, Wang KW, Lee RP, Tsai H. 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. J Clin Nurs 2009;18:22-8.
11. Marra AR, Cal RG, Silva CV, Caserta RA, Paes AT, Moura DF Jr, *et al.* Successful prevention of ventilator-associated pneumonia in an intensive care setting. Am J Infect Control 2009;37:619-25.
12. Rello J, Afonso E, Lisboa T, Ricart M, Balsera B, Rovira A, *et al.* A care bundle approach for prevention of ventilator-associated pneumonia. Clin Microbiol Infect 2013;19:363-9.
13. Pinciroli R, Mietto C, Berra L. Respiratory therapy device modifications to prevent ventilator-associated pneumonia. Curr Opin Infect Dis 2013;26:175-83.
14. Zolfaghari PS, Wyncoll DL. The tracheal tube: Gateway to ventilator-associated pneumonia. Crit Care 2011;15:310.
15. Deem S, Treggiari MM. New endotracheal tubes designed to prevent ventilator-associated pneumonia: Do they make a difference? Respir Care 2010;55:1046-55.
16. Kollef MH, Afessa B, Anzueto A, Veremakis C, Kerr KM, Margolis BD, *et al.* Silver-coated endotracheal tubes

and incidence of ventilator-associated pneumonia: The NASCENT randomized trial. JAMA 2008;300:805-13.
17. Bukhari SZ, Hussain WM, Banjar AA, Fatani MI, Karima TM, Ashshi AM. Application of ventilator care bundle and its impact on ventilator associated pneumonia incidence rate in the adult intensive care unit. Saudi Med J 2012;33:278-83.
18. Restrepo MI, Anzueto A, Arroliga AC, Afessa B, Atkinson MJ, Ho NJ, *et al.* Economic burden of ventilator-associated pneumonia based on total resource utilization. Infect Control Hosp Epidemiol 2010;31:509-15.
19. Caserta RA, Marra AR, Durão MS, Silva CV, Pavao dos Santos OF, Neves HS, *et al.* A program for sustained improvement in preventing ventilator associated pneumonia in an intensive care setting. BMC Infect Dis 2012;12:234.
20. Beattie M, Shepherd A, Maher S, Grant J. Continual improvement in ventilator acquired pneumonia bundle compliance: A retrospective case matched review. Intensive Crit Care Nurs 2012;28:255-62.
21. Joynt GM, Li TS, Griffith JF, Gomersall CD, Yap FH, Ho AM, *et al.* The incidence of deep venous thrombosis in Chinese medical Intensive Care Unit patients. Hong Kong Med J 2009;15:24-30.
22. Tsai HH, Lin FC, Chang SC. Intermittent suction of oral secretions before each positional change may reduce ventilator-associated pneumonia: A pilot study. Am J Med Sci 2008;336:397-401.
23. Alexiou VG, Ierodiakonou V, Dimopoulos G, Falagas ME. Impact of patient position on the incidence of ventilator-associated pneumonia: A meta-analysis of randomized controlled trials. J Crit Care 2009;24:515-22.
24. Drakulovic MB, Torres A, Bauer TT, Nicolas JM, Nogué S, Ferrer M. Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: A randomised trial. Lancet 1999;354:1851-8.
25. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in medical intensive care units in the United States. National Nosocomial Infections Surveillance System. Crit Care Med 1999;27:887-92.
26. Karaoglan H, Yalcin AN, Cengiz M, Ramazanoglu A, Ogunc D, Hakan R, *et al.* Cost analysis of ventilator-associated pneumonia in Turkish medical-surgical intensive care units. Infez Med 2010;18:248-55.