The Prevention of Ventilator-Associated Pneumonia in Surgical Intensive Care Unit Siriraj Hospital

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Objective: *To observe the reduction of Ventilator-Associated Pneumonia (VAP) rates after the conduction of educational program and implementation of VAP care bundles to surgical intensive care units (SICUs) healthcare personnel.*
Material and Method: *Patients were eligible if they were more than 18 years old and on ventilatory support at SICUs. The incidence of VAP was observed retrospectively before and prospectively after the implementation of the one-month educational program. The educational program emphasized VAP prevention. There were 220 patients in the pre-educational group (Group 1) and 220 patients in post-educational group (Group 2). The adherence rate to VAP care bundles according to the educational program was also observed.*
Results: *There were 19.8 and 11.5 episodes of VAP per 1,000 ventilator-days in Group 1 and Group 2, respectively (p = 0.03). Median ventilator days were statistically decreased from 2 days to 1 day after an educational program (p = 0.01). Furthermore, the 28-day mortality rate was decreased from 34 cases (15.5%) to 18 cases (8.2%) in Group 1 and Group 2, respectively (p = 0.01). There was no significant difference in length of ICUs stay, length of hospital stay and antibiotic cost. The adherence to head of bed elevation was improved from 50.1% in Group 1 to 70.3% in Group 2 after the educational program (p = 0.01). The adherence to other bundles was remained high with no significant improvement.*
Conclusion: *The prevention of VAP by implementation of VAP care bundles and the educational program can reduce the VAP rates, 28-day mortality rate and length of ventilator days in surgical ICUs.*

Keywords: *VAP, Incidence, Educational program, Bundles*

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Ventilator-associated pneumonia (VAP) is defined as nosocomial pneumonia occurring in a patient after 48 hours of mechanical ventilation with endotracheal tube or tracheostomy tube[1]. VAP has continued to be a major cause of morbidity and mortality in critically ill patients for decades. The recent study reported that the VAP rates have remained stable over the past decade at approximately 10% in patients ventilated for greater than 48 hours[2]. In Thailand, the rate of VAP was reported continuously high from many teaching hospital intensive care units (ICUs). In Thammasart medical ICUs, the VAP rate was 20.6 per 1,000 ventilator-days in 2003 and decreased to 4.2 per 1,000 ventilator-days in 2005 after the implementation of educational program to reduce VAP[3]. In Siriraj surgical intensive care units (SICUs), from a retrospective study between June 1st, 2010 and June 30th, 2011, the VAP rate was 9.2% or 8.12 per 1,000 ventilator-days[4]. Therefore, VAP has been continuing to be the common nosocomial infection in critically ill patients.

The American Thoracic Society and the Infectious Diseases Society of America recommended the intervention in form of bundles to reduce the rate of VAP[5-11]. However VAP rates remained high even these scientific supported intervention have been implemented as bundles of care in ICUs. In Siriraj general SICUs, the VAP prevention protocol has been implemented as the "WHAP" campaign for years, in which stands for Weaning, Hand hygiene, Aspiration

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precautions and Preventing contaminations. The "WHAP" bundles were originally created from the Division of Nursing as a policy aimed to reduce the rate of VAP. Nevertheless, the incidence of VAP in SICUs has not obviously improved. Therefore the adherence to the bundles as well as the appropriateness of the content of the protocol remained questionable.

Previous studies conducted in Thailand found that the educational program and the VAP care bundles implementation could decrease VAP incidence[3,4,12]. However the adherence to the protocol was not documented. Several processes of care are contributing to the VAP prevention bundles, for example, the head of bed elevation, daily weaning assessment, deep vein thrombosis (DVT) prophylaxis and endotracheal tube cuff pressure monitoring. However, some details are not applicable in specific population. Therefore, the previous bundles have been revised on the basis of the current scientific evidence and the feasibility in process of cares for the SICUs Siriraj Hospital.

The aims of the present study were to demonstrate the improvement in the VAP rates and the adherence to VAP care bundles after the implementation of the educational program regarding the revised VAP prevention protocol in SICUs at Siriraj Hospital.

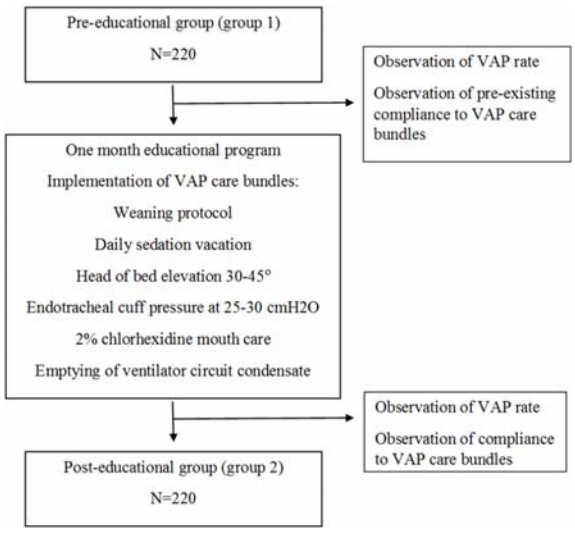
Material and Method

Siriraj SICUs is a 14-bed ICUs operated in the tertiary care university hospital. The majority of the patients are from general surgical wards and operating theaters. Neurosurgical, cardiovascular-thoracic and trauma patients are admitted to other separated ICUs. The SICUs is a closed unit covered by intensivists and multidisciplinary consultation teams. The nurse-patient ratio is 1: 1 and 1: 2 during daytime and nighttime shift, respectively. The physician teams consist of one to two critical care fellowships and four to five anesthesiology residents that are supervised by one attending staff.

This quasi-experimental study was approved by the Institutional Review Board (Si 504/2011). The study period was between September 2011 and September 2013. Authors implemented the one-month educational program to the ICUs personnel, mainly the nurses and residents. Thereafter, patient outcomes including the VAP rates, the length of ventilatory days, length of ICUs stay, length of hospital stay, antibiotic cost and mortality rate were measured. The educational program was a one-hour formal lecture, posters and brochures. The pre-test and post-test were conducted to evaluate the efficacy of the program. The VAP care bundles were implemented after the educational program. The components of the VAP care bundles "WHAP" campaign included the following: weaning according to a weaning protocol[13]; daily sedation vacation; head of bed elevation at least 30 to 45 degree; measure endotracheal cuff pressure every 6 hours and keep at 25 to 30 cm H_2O; use 2% chlorhexidine mouth care; and emptying of ventilator circuit condensate.

The patients were categorized in two sections which the first section referred to a pre-educational group (Group 1) and the second section referred to a post-educational group (Group 2) (Fig. 1). The number of patients was 220 per group. Group 1, data were obtained retrospectively from chart review whereas the post educational group, data were observed prospectively. The diagnosis of VAP in Group 1 was based on doctors' progress notes, nurses' records, chest x-ray and data from the Center for Nosocomial Infection Control, Siriraj Hospital.

The adherence rates of VAP care bundles were collected in both groups by a single observer. The adherence rate to VAP care bundles was observed before the educational program to identify the pre-existing compliance to the bundles in the ICUs by the single observer with the same way as performed after an educational program. Some bundles had been promoted before but all of them were not formally implemented. In Group 1, the data of the adherence rate



VAP = ventilator associated pneumonia

Fig. 1 Study flow.

to VAP care bundles were retrospectively collected from chart review in duration of two months prior to the educational program. In Group 2, the adherence rate of VAP care bundles was measured with direct observation for head of bed elevation and chart review for other bundles which were performed one time per day. If the observer had some questions, the nurses or residents would be interviewed for further information. The inclusion criterion was adult patients who required ventilatory support via endotracheal tube or tracheostomy tube. The exclusion criterions were patients diagnosed VAP within 48 hours after SICUs admission and patients who were referred from other hospitals. VAP was defined as nosocomial pneumonia occurring in a patient after 48 hours of mechanical ventilation with endotracheal tubes or tracheostomy tubes and a diagnosis of pneumonia was made if they met 2/3 of fever >38°C, leukocytosis or leukopenia, or purulent sputum plus new or progressive infiltration on chest x-ray[14]. Late VAP was defined as pneumonia that occurred after four days of intubation.

Statistical analysis

The sample size required to estimate a VAP rate of 5 per 1,000 ventilator days with 95% confidence interval of $\pm$3 per 1,000 ventilator-days using simple random sampling was 220 per group. Continuous variables were expressed as means with standard deviation (SD) or median with interquartile range (P_{25},P_{75}) and compared between groups using Student's t-test. Categorical variables were expressed number with percentage and compared between groups using the Chi-square test or fisher's exact test as appropriate. A two-sided alpha level of 0.05 was required for statistical significance. Data were analyzed using PASW Statistics for Windows, 17.0 Chicago: SPSS Inc.

Results

Four hundred and forty SICUs patients who required mechanical ventilation were enrolled in the study. Two hundred and twenty patients were categorized in Group 1 and another 220 patients were in Group 2. The demographic and clinical characteristics of patients enrolled in this study were presented in Table 1. There was no significant difference between the two groups regarding age, sex, body mass index, acute physiology and chronic health evaluation (APACHE) II scores, co-morbidities, type of patients, duration and operation. There were six patients in group 1 and twelve patients in Group 2 that did not undergo

Table 1. Baseline characteristics

Characteristics	Group 1 (n = 220)	Group 2 (n = 220)	*p*-value
Age	62.6$\pm$18.3	62.3$\pm$17.7	0.89
Gender: Female	112 (50.9)	9 (43.1)	0.10
Body mass index (kg/m^2)	22.80$\pm$5.10	23.10$\pm$6.5	0.61
APACHE II	11.90$\pm$5.20	10.70$\pm$5.1	0.09
Surgical patients	21 (97.20)	20 (94.5)	0.27
Co-morbidities			
Cardiovascular system	11 (53.1)	10 (5)	0.44
Respiratory system	30 (13.6)	28 (12.7)	0.57
Chronic liver disease	11 (5)	15 (68.1)	0.41
Diabetes mellitus	42 (19)	34 (15.4)	0.31
Immunocompromised host	5 (2.2)	1 (0.4)	0.12
Cerebrovascular disease	10 (4.5)	6 (2.7)	0.30
Chronic kidney disease	20 (9)	21(9.5)	0.87
Type of operation			
Abdominal surgery	75 (35)	80 (38.4)	0.61
Vascular surgery	20 (9.3)	19 (9.1)	0.86
Head & neck surgery	20 (9.3)	24 (11.5)	0.52
Spine	14 (6.5)	7 (3.3)	0.11
Transplantation	7 (3.2)	5 (2.4)	0.55
Duration of operation (hr)	4 (2.30-7)	4 (2-6)	0.21

Data presented as number (%), means with standard deviation (SD) or median with interquartile range (IQR)
APACHE = Acute Physiology and Chronic Health Evaluation

any operations before ICU admission. Finally, there were 214 patients in Group 1 and 208 patients in Group 2 considered as surgical patients. Forty ICU nurses (70%) completed the entire educational program. The test contained 20 multiple choice questions. The mean score of correct answers on the pre-test was 15.5 and increased significantly in the post-test to 17.5 ($p<0.01$).

The clinical data and outcomes were showed in Table 2. There were 19.8 episodes of VAP per 1,000 ventilator-days in Group 1 and 11.5 episodes of VAP per 1,000 ventilator-days in Group 2 ($p = 0.03$). The incidence of late VAP was also decreased from 29 (13.1%) in Group 1 to 16 (7.2%) in Group 2 ($p = 0.04$). Similarly, median ventilator days were significantly decreased from 2 days to 1 day after an educational program ($p = 0.01$).

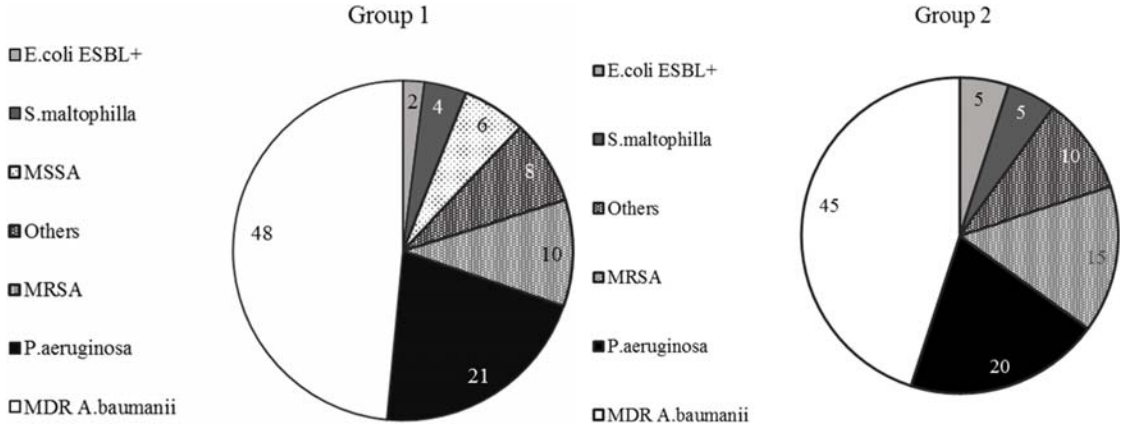
The 28-day mortality rate was decreased from 34 cases (15.5%) to 18 cases (8.2%) in Group 1 and Group 2 respectively ($p = 0.01$). The intervention had no impact on the median length of ICUs stay (3, IQR 2 to 8 days in Group 1 vs. 3, IQR 1 to 5 days in Group 2, $p = 0.05$) and the length of hospital stay (17, IQR 11 to 27 in Group 1 vs. 17, IQR 9 to 30 in Group 2, $p = 0.96$). The median costs of antibiotics were not significantly different between Group 1 and Group 2 (82.8 US Dollars, IQR 12.7 to 459.4 vs. 61.1 US Dollars, IQR 12.5 to 414.7, $p = 0.99$, respectively).

The pattern of microorganisms isolated from patients with VAP was not significantly different (Fig. 2). The two most common microorganisms were *Acinetobacter baumannii* (48% in Group 1 vs. 45% in Group 2) and *Pseudomonas aeruginosa* (21% in Group

Table 2. Impact of the educational program on outcomes

	Group 1 (n = 220)	Group 2 (n = 220)	*p*-value
VAP/1,000 ventilator days	19.8	11.5	0.03
Late VAP	29 (13.1)	16 (7.2)	0.04
Ventilator days (d)	2 (1 to 6)	1 (1 to 4)	0.01
length of ICU stay (d)	3 (2 to 8)	3 (1 to 5.7)	0.05
length of hospital stay (d)	17 (11 to 26.7)	17 (9.2 to 30)	0.96
Antibiotic cost (US Dollars)	82.8 (12.7 to 459.4)	61.10 (12.5 to 414.7)	0.99
28-day mortality	34 (15.5)	18 (8.2)	0.01

Data presented as numbers (%), means with standard deviation or median with interquartile range (IQR)
VAP = ventilator associated pneumonia.



Group 1 = pre-educational group; Group 2 = post-educational group. MDR *A. baumanii* = multidrug-resistant *Acinetobacter baumannii*; *P. aeruginosa* = *Pseudomonas aerugiosa*; MRSA = Methicillin-resistant *Staphylococcus aureus*; MSSA = Methicillin-sensitive *Staphylococcus aureus*; *S. maltophilla* = *Stenotrophomonas maltophilia*; *E. coli* ESBL+ = Extended-spectrum beta-lactamase-positive *Escherichia coli*.

Fig. 2 Microbiology diagnosis in ventilator associated pneumonia. Data presented as percentage from total identified organisms.

1 vs. 20% in Group 2).

The percentages of the observation days from the total observation days in the study period were 84.9 in Group 1 and 87.1 in Group 2. Given that only single investigator observed the adherence in this study, the observation could not be complete in every day during study period. The adherence rate of VAP care bundles was improved only for the head of bed elevation after the educational program (50.1% in Group 1 vs. 70.3% in Group 2, $p = 0.01$). The adherence to other bundles was not significantly different before and after educational program (Fig. 3).

Discussion

The results of this study confirmed the findings from previous literatures in term of an educational program on VAP prevention did improve the VAP rates[3,4,15,16]. In addition, the authors also demonstrated a decrease in VAP rate as well as the increase in adherence rate to VAP care bundles at the same time. This study revealed that the educational program was able to reduce the VAP rates from 19.8 to 11.5 per 1,000 ventilator-days. The authors also demonstrated the reduction in the mortality rate and ventilator days after an implementation of educational program. Although the definition of VAP was recently updated from Center for Disease Control and Prevention (CDC)/National Healthcare Safety Network (NHSN) Protocol Corrections, Clarification, and Additions in April 2013[17]. The definition of clinically defined pneumonia was similar to the definition in this study.

The overall adherence rate to VAP care bundles in this study was above 80% except for the head of bed elevation. The adherence rate to weaning assessment and sedation vacation were substantially

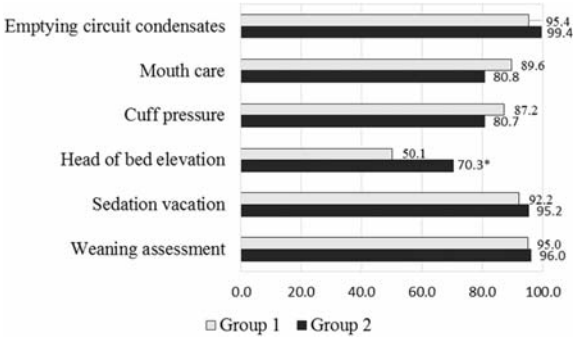


Fig. 3 Percentage of adherence rate to VAP care bundles. Group 1 = pre-educational group; Group 2 = post-educational group.

high because these two bundles are routinely conducted by the ICUs staffs who were the same team throughout the study. The adherence to the emptying of ventilator circuit condensates was also high because it has been implementing as protocol from the Division of Nurses and easily conducted at bedsides. Consequently, the significant improvement was hardly demonstrated. The adherence to the head of bed elevation was only 50.1% in the pre-educational group, which was much lower as compared to other bundles. Not surprisingly, head of bed elevation was the only bundle, which was improved significantly after the educational program. Leng et al[18] conducted a meta-analysis and found that the risks of developing clinically diagnosed VAP were significantly lower among the patients in semi recumbent 45 degree angle position compared to the patients in lower position. However, there was a systematic review showing that it was uncertain whether a 45 degree head of bed elevation was effective to prevent clinically suspected VAP[19], microbiologically confirmed VAP and mortality. Nevertheless, these randomized controlled trials did not demonstrate disadvantages of the head of bed elevation in terms of an increase risk in thromboembolism or hemodynamic instability. The accuracy of the degrees of the head of bed elevation might be the considerable factor. Previously, the assessment of the degree elevation of the head of bed was performed by the estimation. Nowadays, it is accurately adjusted with the scale that shows number of degrees at beds' side. The former study showed that the negative outcomes of this bundle did not report the accuracy of the degrees of the elevation[19]. Even though the efficacy of head of bed elevation to prevent VAP is still debatable, the authors recommend this strategy to be one of the VAP care bundles as long as there is no harmful evidence regarding this procedure.

There was a clear evidence that the implementation of appropriate VAP care bundles could reduce the incidence of VAP[20,21]. However the difference in VAP care bundles among ICUs was supposed to affect the VAP rates. Sundar et al[15] demonstrated the zero VAP incidence at American Fork Hospital which VAP care bundles consisted of head of bed elevation, oral chlorhexidine care every 12 hours, daily sedation vacation, use of continuous subglottic suction, change from a heated moisture exchanger to heated-wire ventilator circuit with humidifier, DVT prophylaxis (anticoagulants, sequential compression stockings), stress ulcer prophylaxis (H2 blockers or proton pump inhibitors). The VAP care bundles of this hospital were much broader compared to those using

in this study. It might result in the difference in VAP rates. On the other hand, the similar VAP care bundles in the different hospitals were not always associated with the same outcomes. Sundar et al[15] demonstrated the discrepancy of the VAP incidence between the two hospitals with the same VAP care bundles and intensivists. The two hospitals were Utah Valley Regional Medical Center (UVRMC), which had VAP rate of 2.41/1,000 ventilator days and American Fork Hospital (AFH) which had zero VAP rate. These two hospitals differed significantly in terms of ICU size, length of ventilator stays and patient characteristics. Each intensive care unit has their own characteristics that can influence the selection of the appropriate VAP care bundles.

The implementation of VAP care bundles can be accomplished by creating the effective educational program. In this study, the basic knowledge regarding VAP of the healthcare personnel was significantly improved after the educational program that included posters and lectures. The results from several studies also confirmed the efficacy of the educational program in the improvement of VAP rates[3,12,22]. Moreover, one study demonstrated the improvement not only knowledge of healthcare workers but also the cognitive factors after the educational program[23]. The cognitive factors are composed of many aspects such as perception of the seriousness of VAP or self-assessment of the abilities to perform VAP prevention.

The pattern of microorganisms reported in this study was not significantly different from other studies in Thailand. The major organisms causing VAP in ICUs were gram negative bacterias and the most common organism is *Acinetobacter baumannii*[4,24,25].

A few limitations of this study should be addressed. The diagnosis of VAP in this study showed some limitation because the diagnosis was made from a chart review in the pre-educational group. However, the diagnosis of VAP in this study was similar to the CDC algorithms for clinically defined pneumonia[17], which was practical and easy to use. Thus, it should minimize the effect of the diagnosis between the pre-educational (retrospective) and post-educational (prospective) group. Moreover, the diagnosis of VAP was made by the same person throughout the study. In contrast to the RCT, other unmeasured factors coincided with the intervention might result in the improvement in the VAP rates and mortality rate. As mentioned, both of the VAP care bundles and the educational program in this study were performed in only one SICUs at a single medical university hospital, the applicability to other types of ICUs or other institutions might be questionable. However, this study demonstrated that the combination of simple bundles and uncomplicated educational program could reduce the VAP rate and short-term mortality, which may be generalizable to other hospitals.

In Siriraj SICUs, the prevention of VAP by implementation of VAP care bundles and the educational program can reduce the VAP rates, 28-day mortality rate and length of ventilatory days. However, we recognized that the VAP incidence remained high. The repetition of the educational program in order to sustain the reduction in VAP rates is mandatory required. Moreover, the intervention does not require high cost of investment that will be the major concern in developing countries. In addition, the discrepancy between published guidelines and actual practices might affect outcomes. Therefore, not only the frequency of educational program but the audit systems to assure the adherence rate are contributed to the better outcomes.

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Potential conflicts of interest

None.

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การป้องกันการเกิดปอดอักเสบติดเชื้อจากการใช้เครื่องช่วยหายใจในหออภิบาลผู้ป่วยวิกฤตทางศัลยกรรมในโรงพยาบาลศิริราช

ชวิกา พิสิฏฐศักดิ์, รัชดา เจิดรังษี, สุสัณห์ อาศนะเสน, สวิตา คณาวิฑูรย์, รุ่งรวี ละวรรณวงศ์, ปิญาพร ภูลายเรียบ, อรอุมา ชัยวัฒน์

วัตถุประสงค์: *เพื่อศึกษาถึงการลดลงของอุบัติการณ์การเกิดปอดอักเสบติดเชื้อจากการใช้เครื่องช่วยหายใจในหออภิบาลผู้ป่วยวิกฤตทางศัลยกรรมหลังให้การจัดอบรมและรณรงค์การป้องกันการเกิดปอดอักเสบติดเชื้อจากการใช้เครื่องช่วยหายใจกับบุคลากรทางการแพทย์ภายในหออภิบาล*

วัสดุและวิธีการ: *เกณฑ์การคัดเลือกผู้ป่วยเข้าร่วมการวิจัย ได้แก่ ผู้ป่วยอายุมากกว่า 18 ปี ได้รับการช่วยหายใจด้วยเครื่องช่วยหายใจที่หออภิบาลผู้ป่วยศัลยกรรม อุบัติการณ์การเกิดปอดอักเสบติดเชื้อจากการใช้เครื่องช่วยหายใจจะถูกศึกษาแบบย้อนหลังและไปข้างหน้าหลังดำเนินการจัดอบรม โดยการอบรมจะมุ่งเน้นถึงหลักปฏิบัติสำคัญในการป้องกันการเกิดปอดอักเสบติดเชื้อ โดยผู้ป่วยมีจำนวน 220 คนต่อกลุ่ม แบ่งเป็น กลุ่มก่อนได้รับการอบรม (กลุ่ม 1) และกลุ่มหลังได้รับการอบรม (กลุ่ม 2) มีการเก็บรวบรวมอัตราการปฏิบัติตามหลักการเพื่อป้องกันการเกิดปอดอักเสบติดเชื้อจากการใช้เครื่องช่วยหายใจก่อนและหลังการอบรม*

ผลการศึกษา: *อุบัติการณ์การเกิดปอดอักเสบติดเชื้อจากการใช้เครื่องช่วยหายใจในกลุ่ม 1 และกลุ่ม 2 เท่ากับ 19.8 และ 11.5 ต่อ 1,000 วันของการใช้เครื่องช่วยหายใจตามลำดับ (p = 0.03) พบว่ามีการลดลงของค่ามัธยฐานของระยะเวลาในการใช้เครื่องช่วยหายใจในกลุ่ม 1 จาก 2 วัน เป็น 1 วันในกลุ่ม 2 (p = 0.01) และมีการลดลงของอัตราตายจากร้อยละ 15.5 ในกลุ่ม 1 เป็นร้อยละ 8.2 ในกลุ่ม 2 (p = 0.01) ไม่พบความแตกต่างของระยะเวลาการรับการรักษาตัวในหออภิบาลผู้ป่วยระยะเวลาการรับการรักษาตัวในโรงพยาบาล และค่าใช้จ่ายในการใช้ยาปฏิชีวนะ หลักปฏิบัติในการลดการเกิดปอดอักเสบติดเชื้อในด้านการยกศีรษะสูงจากเตียงมีการพัฒนาขึ้นอย่างมีนัยสำคัญจากร้อยละ 50.1 ในกลุ่ม 1 เป็นร้อยละ 70.3 ในกลุ่ม 2 (p = 0.01) ความร่วมมือในหลักปฏิบัติอื่น ๆ อยู่ในระดับสูงคงที่*

สรุป: *การจัดการอบรมเพื่อรณรงค์การป้องกันการเกิดปอดอักเสบติดเชื้อจากการใช้เครื่องช่วยหายใจ สามารถลดอุบัติการณ์การเกิดปอดอักเสบติดเชื้อระยะเวลาการใช้เครื่องช่วยหายใจ และอัตราตายในหออภิบาลผู้ป่วยวิกฤตทางศัลยกรรมได้*