Incidence of Ventilator-Associated Pneumonia (VAP) After the Institution of an Educational Program on VAP Prevention

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Objective: *Demonstrate if the institution of an educational program on VAP and its prevention is effective in helping reduce the incidence of VAP in a surgical ICU.*
Material and Method: *An educational program on VAP and its prevention, which consisted of a 1-hour formal lecture, an educational handout, and a pre-and post-test exam was given to the nursing staff beginning in April 1st, 2003. Reminding posters were posted throughout the ICU. The pre-and post-intervention clinical data that included age, sex, diagnosis, APACHE II, ventilator days, and incidence of VAP were collected. VAP was considered to have occurred only after the patient had been on mechanical ventilation for greater than 48 hours. The primary outcome measure was the incidence of VAP. The secondary outcome measures were duration of the ICU and hospital stay, and the ICU and hospital mortality. Values were expressed as mean ± standard deviation, and median (range). Multiple logistic regression analysis of various variables was used to identify risk factors for the occurrence of the VAP.*
Results: *Eight-five patients in Pre- (July 1st, 2002 to June 30th, 2003) and 89 patients in post- (July 1st, 2003 to June 30th, 2004) intervention met the inclusion criteria. The incidence of VAP decreased from 39.7 per 1000 ventilator-day to 10.5 per 1000 ventilator-day (p-value < 0.001) after the institution of an educational program. The ICU, hospital length of stay, and the mortality rate remained unchanged. Age and the interventional program were found to correlate with the occurrence of VAP.*
Conclusion: *An institution of an educational program on VAP and its prevention helps reduce the incidence of the VAP at the study institution but does not affect the ICU, hospital length of stay, and the mortality rate.*

Keywords*: Ventilator-associated pneumonia, Education, Intervention*

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Pneumonia is the most common nosocomial infection confronted by all modern era intensive care units (ICU)[1-3]. Patients in the ICU have certain characteristics or specific risk factors that predispose them to developing pneumonia[4-9]. The majority of these patients will be intubated and on mechanical ventilators. That in itself is a risk factor, hence the term "ventilator-associated" pneumonia (VAP) or perhaps a more appropriate term, "tube-associated" pneumonia (TAP) as suggested by Brown et al[10]. VAP leads to an overall increase in ICU length of stay, an increase in medical costs[10-13], and may affect the mortality rate[7-18]. Certain clinical approaches coupled with dedicated healthcare practitioners[19] can help prevent or reduce the incidence of VAP. One approach is an institution of the hospital infection control and surveillance[20], which has been shown to reduce the incidence of nosocomial infections and is the current practice standard for all hospitals. Another example is an institution of a weaning protocol, which has been shown to help reduce the

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incidence of VAP by reducing ventilation time[21]. Recently, several studies suggested that the institution of an educational program on VAP prevention could also help reduce the incidence of VAP[22,23]. The objective of the present study was to determine the incidence of VAP and evaluate the effectiveness of an educational program on the VAP prevention in the reduction of the incidence of VAP in a surgical ICU.

Material and Method

The present study received the approval from the Institution Review Board of Ramathibodi Hospital.

The location of the present study was a 6-bed surgical intensive care unit (ICU) of a 1000-bed University-affiliated tertiary referral hospital. A VAP educational program modeled after Zack et al[23] was instituted and consisted of a 1-hour formal lecture to the 18 ICU nursing staff (the authors have no respiratory therapists) who were also provided with a hand-out detailing the definition, the epidemiology, the incidence, the associated morbidity and mortality, the pathogenesis, the risk factors, and the necessary measures to help reduce or prevent the occurrence of VAP. A 10-question pre-and post-lecture exam was given immediately after the lecture and another formal lecture was given after a 6-month interval. Although the authors decided not to set up a certain passing score, all nurses scored more than 50% after the lecture. The authors believed that the nurses would also learn the materials from daily formal discussion rounds and posters containing VAP preventive steps that were posted throughout the ICU. The 1-year pre-intervention clinical data (July 1st, 2002 to June 30th, 2003) were obtained retrospectively from chart review, while post-intervention data (July 1st, 2003 to June 30th, 2004) were collected prospectively. The first lecture was given in April 2003 and a second after a 6-month interval. The clinical data collected and kept in an Excel data format were demography, ICU admitting diagnosis, APACHE II score[24], operative procedures, the clinical course and outcome including the length of ICU and hospital stay. The primary end-point of interest was the occurrence of VAP. Secondary outcomes included the 30-day ICU and the overall 60-day hospital death, and the overall ICU and hospital length of stay (LOS). VAP was defined according to Garner et al[25] and required that the patients (1) be on the mechanical ventilator > 48 hours, (2) have a new onset and persistent chest x-ray infiltrates, (3) have a fever > 38 C, (4) have a leukocyte count > 12000/mm^{3,} (5) have a purulent tracheobronchial sputum with quantitative bacterial count > 10^5 colony-forming units/ml, a Gram's stain showing > 25 neutrophils with <10 epithelial cells per field, and (6) have a deterioration of oxygenation[26], The determination of VAP was made both during the pre-and post-intervention by the hospital's Infection Control (IC) team who was not a part of the study team. The research nurses also kept track of the occurrence of VAP during the post-intervention period for a comparison with the records made by the hospital's IC team.

Statistical analysis

The data were summarized as mean $\pm$ standard deviation (SD), median (range), or proportions as appropriate. The means were tested using the unpaired t-test and the proportions with the Chi-square test. Non-parametric continuous variables were tested with the Wilcoxon ranksum test while the difference in the incidences of VAP (per 1000 ventilator-days) was tested using non-parametric bootstrap tests with 10000 resamples. Multiple logistic regression analysis was performed to identify independent risk factors associated with VAP. All data were analyzed with the statistical software program STATA v. 7 (Stata Corp, College Station, TX, USA). All p-values < 0.05 were considered statistically significant.

Results

There were 246 and 287 patients treated during the pre-and post-intervention period respectively, but only 223 charts were available for review from the pre-intervention period. In general, the overall demography, services using the ICU, and admitting diagnosis were similar between the two cohorts (Table1). After excluding patients who were on mechanical ventilation for less than 48, there were 85 and 89 patients from the pre-and post-intervention periods respectively, and these made up the presented study groups. The clinical data and outcomes are summarized in Table 2. The overall demography and APACHE II score were similar between the two study groups. There was good agreement between the incidence of VAP as reported by the IC and as recorded by the research nurses. The occurrence of VAP went down from 49% to 12% ($p < 0.001$) with the decrease in the incidence of VAP per 1000 ventilator-days from 39.7 to 10.5 ($p < 0.001$). The median ICU length of stay (9 days, range 3to 87 days versus 10 days, range 3 to 62 days), and the hospital stay (36 days, range 3to 153 days versus 28 days, range 3 to 299 days) were not statistically different between the pre-and the post-intervention groups. Similarly,

Table 1. Characteristics of all patients

	Pre-Intervention	Post-Intervention	p-value
Total	223	287	
Age (mean ± SD)	55.3 ± 17.6	55.6 ± 18.0	0.851[a]
Sex: number male (%)	123 (55)	169 (59)	0.399[b]
APACHE II (mean ± SD)	12.5 ± 9.2	12.2 ± 8.2	0.698[a]
Services: number (%)			
Neurosurgery	66 (30)	68 (24)	0.286[b]
General Surgery	85 (38)	137 (48)	
Trauma	23 (10)	35 (12)	
Vascular	18 (8)	20 (7)	
Urology	12 (5)	13 (5)	
Plastic	3 (1)	3 (1)	
Medical	15 (7)	11 (4)	
Transplant	1 (0)	-	
Diagnosis: number (%)			
Post-operative	81 (36)	112 (39)	0.785[b]
Neurosurgery	60 (27)	62 (22)	
Sepsis	20 (9)	31 (11)	
Trauma	23 (10)	30 (10)	
Acute respiratory failure	25 (11)	28 (10)	
GI Bleed	3 (1)	6 (2)	
Other	11 (5)	18 (6)	

a p-values by unpaired t-test
b p-values by Chi-square test

Table 2. Characteristics and outcomes in the study groups

	Pre-Intervention (n = 85)	Post-Intervention (n = 89)	p-value
Age (years). Mean ± SD	55.2 ± 16.5	56.9 ± 19.8	0.540[a]
Sex: number male (%)	50 (59)	52 (58)	0.958[b]
APACHE II: Mean ± SD	16.8 ± 8.0	16.2 ± 6.3	0.512[a]
VAP: n (%)	42 (49.4)	11 (12.4)	<0.001[b]
VAP/ventilator days x 1000	39.7	10.5	<0.001[c]
Days on ventilator: median (range)	7 (3-67)	7 (3-60)	0.916[d]
ICU LOS: median (range)	9 (3-87)	10 (3-62)	0.918[d]
Hospital days: median (range)	36 (3-153)	28 (3-299)	0.180[d]
30-day ICU mortality: n (%)	20 (23.5)	28 (31.5)	0.242[b]
60-day hospital mortality: n (%)	34 (40.0)	41(46.1)	0.419[b]
Ventilator utilization (%)[e]	83.3	80.6	0.540[c]

a p-values by unpaired t-test
b p-values by Chi-square test
c p-values by non-parametric bootstrap test with 10000 resamples
d p-values by Wilcoxon ranksum test
e ventilator utilization is defined as average ventilator-days divided by average ICU LOS

the 30-day ICU and the 60-day hospital mortality rates were also not statistically different (24% versus 32%, p = 0.242; and 40% versus 46%, p = 0.419, respectively). However, Sepsis/MOF related to pneumonia as a cause of death went down from eight cases to one case from the pre-to the post-intervention period (Tables 3, 4). A multiple logistic regression analysis identified age and the intervention program as significant risk factors for

Table 3. Cause of death in the study groups

	Pre-Intervention (n = 20)	Post-Intervention (n = 28)
Sepsis/ MOF	13	12
Pneumonia-related	8	1
Non-pneumonia-related	5	11
Cardiopulmonary	-	6
CNS	7	8
End-stage malignancy	-	-
Renal failure	-	1
Liver failure	-	1

Table 4. Sepsis/MOF cause of death

Pre-Intervention (n = 13)	Post-Intervention (n = 12)
Pneumonia-related (number)	Pneumonia-related (number)
Acinetobacter-MDR (2)	Klebsiella/acinetobacter (1)
Acinetobacter-MDR, MRSA (2)	Non-pneumonia-related (number)
Pseudomonas, MRSA (2)	Soft tissue sepsis (4)
Pseudomonas, acinetobacter (1)	Intraabdominal sepsis (3)
Pseudomonas (1)	Cholangitis (2)
Non-pneumonia-related (number)	CNS sepsis (1)
Intraabdominal sepsis (2)	Enterocutaneous fistula/sepsis (1)
Cholangitis (1)	
Mediantinitis (1)	
Pressure sore sepsis (1)	

Table 5. Independent risk factors for VAP

	Odds ratio	95% confidence interval	p-value
Age	1.04	(1.02-1.06)	0.001
Intervention	9.03	(3.94-20.67)	<0.001

Table 6. Written examination scores

	Pre-lecture	Post-lecture	p-value[c]
1-day[a]: mean ± SD	42.2±15.2	67.8±13.1	<0.001
6-months[b]: mean ± SD	51.2±11.4	80.9±19.2	<0.001

a 1-day refers to 1 day after the first lecture
b 6-months refers to 6 months after the first lecture, at which a second lecture was given
c p-values by paired t-test

the development of VAP (Table 5). The results of pre- and post intervention written examinations provided to the nurses showed significant improvements at both 1 day and 6 months after the first and second interventions (lectures), respectively (Table 6).

Discussion

The present study confirmed the findings by Zack JE et al [23] that an educational program on VAP prevention given to healthcare staff helped reduce incidence of VAP. Although the setting of the current study was a smaller scale, 6-bed surgical ICU of a 1000-bed University-affiliated tertiary hospital in a developing country, the clinical ramifications, and benefits associated with VAP reduction remain the same. The incidence of VAP was reduced from 39.7 to 10.5 per 1000 ventilator-days, a remarkable 74% reduction. This incidence is close to the 11.8per 1000 ventilator-days, the benchmark according to the National Nosocomial Infections Surveillance data from the Centers for Disease

Control, USA during the period from 1995to 1999[2]. This makes the incidence of VAP in our ICU comparable to that of the developed countries.

Contrary to expectations, in the present study the ICU and the hospital length of stay (LOS) did not improve as the incidence of VAP went down. The ICU median LOS went up from 9 to 10 days, but the overall hospital LOS went down from 36 to 28 days but these differences were not statistically significant. There are several possible explanations. Firstly, the present study design might not be appropriate for answering this question. Those studies[12-16] that concluded that the occurrence of VAP lead to an increase in ICU LOS and used a matched case-control design. Secondly, the interplay between the complexity of each ICU patient population and the ICU setting might have some influence on this outcome, as has been recognized by several experts in this field[7,8,15,16,27]. Ramathibodi Hospital is an inner city hospital and serves as a referral center for many provincial hospitals. Once patients are admitted, there is nowhere else to go. The number of beds and staffing capacity will always remain limited. The annual surgical ICU admission rate in Ramathibodi Hospital went up 16% as the overall ICU length of stay went down from 7.4 days to 6.2 days (Table 1). But admitting and discharging patients from the ICU depend not only on the condition of the patient but also on such issues as the bed and staffing availability and social considerations, which in essence makes the ICU and hospital LOS inappropriate measures of quality care.

Similarly, there is no good explanation why the 30-day ICU and overall 60-day hospital mortality rates did not improve after the intervention (24% vs 32%, and 40% vs 46%, respectively) (Table2). The issue of the contribution of VAP to ICU mortality appears somewhat controversial in the literature. Fagon, et al[12] and Bercault et al[13] concluded that VAP contributes to an increase in ICU mortality, while Papazian et al[15], and Bergeon et al[16] suggested otherwise. However, the populations studied were somewhat different and heterogeneous. In another study by R-Ferrari et al[14] that included moderate to severe traumatic head injury patients, the authors concluded that VAP increases the ICU LOS but not on the overall mortality. Interestingly the authors observed that pneumonia-related MOF/sepsis as a cause of death decreased from eight cases to one (Table 6) from the pre- to the post- intervention period, which none of the previous studies have looked at. Many of the presented patients from the post-intervention period succumbed to a non-pneumonia-related MOF/sepsis as a cause of death. In essence, the authors cannot state with certainty the true relationship between VAP and ICU or hospital mortality. The authors' opinion leaned towards the conclusions drawn by Torres, et al [7] and Rodriquez, et al [8] that the underlying disease or the condition of the patient is the most important predictor of ICU mortality, whether or not VAP actually occurred.

The authors recognized many weaknesses in the present study. First, due to the retrospective nature of the study, bias might occur because of the missing charts and the inaccuracy of the chart record. Second, the authors recognized the difficulty and the non-specific nature of making a diagnosis of pneumonia[28]. This bias was minimized by letting the Infection Control team determine the occurrence of VAP using standardized non-quantitative definition of pneumonia[25,26]. Finally, during this same time period the authors also instituted a new weaning protocol in the ICU. However, since this protocol aimed to reduce ventilator days but did not do so (Table 2) it probably did not contribute significantly to the decrease in the VAP incidence.

In conclusion, the present study confirmed that an institution of an educational program on VAP and its prevention could probably help reduce the incidence of VAP. While the authors observed no changes in either the ICU, hospital LOS or mortality, the authors believed it helped improve the overall patient care, and can serve as a model for other ICUs, especially in developing countries.

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อุบัติการณ์การเกิดปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจภายหลังให้ความรู้และกำหนดมาตรการป้องกัน

ณรงค์ กุลวทัญญู, อารีย์ บุญบวรรัตนกุล, ยุภา สุนทรกิจ, ช่อทิพย์ คชเสนี, ภาณุวัฒน์ เลิศสิทธิชัย

วัตถุประสงค์: *เพื่อศึกษาผลของการให้ความรู้และมาตรการป้องกันปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจต่อการลดอุบัติการณ์ในผู้ป่วยวิกฤตทางศัลยกรรมโรงพยาบาลรามาธิบดี*

วัสดุและวิธีการ: *การศึกษานี้ คณะผู้วิจัยใช้เวลา 1 ชั่วโมง (วันที่ 1 เมษายน พ.ศ. 2546) จัดโปรแกรมการสอนให้ความรู้เรื่องปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจ และวิธีป้องกันแก่พยาบาลประจำการพร้อมกับประเมินความรู้ของพยาบาลโดยให้ทำแบบทดสอบก่อนและหลังการสอน หลังจากนั้นให้ปฏิบัติตามมาตรการป้องกันปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจที่ปิดบนผนังในหอผู้ป่วยวิกฤต เก็บข้อมูลเกี่ยวกับ อายุ เพศ การวินิจฉัยโรค คะแนนความรุนแรงของการเจ็บป่วย จำนวนวันที่ใช้เครื่องช่วยหายใจ อุบัติการณ์การเกิดปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจ ทั้งก่อนและหลังโปรแกรมให้ความรู้ การพิจารณาว่าเกิดปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจนั้น ผู้ป่วยต้องใช้เครื่องช่วยหายใจนานมากกว่า 48 ชั่วโมง บันทึกอุบัติการณ์การเกิดปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจ วัดหาระยะเวลาที่นอนในหอผู้ป่วยวิกฤตและระยะเวลาที่นอนในโรงพยาบาล และอัตราการตาย นำเสนอข้อมูลโดยใช้ค่าเฉลี่ย ค่าเบี่ยงเบนมาตรฐาน และค่ามัธยฐาน (ค่ากลาง) วิเคราะห์ความสัมพันธ์ของตัวแปรกับอุบัติการณ์การเกิดปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจโดยใช้สถิติถดถอยพหุโลจิสติกส์ที่ระดับนัยสำคัญทางสถิติ $p \leq .05$*

ผลการศึกษา: *ผู้ป่วยจำนวน 85 คนเข้าโครงการวิจัยในช่วงก่อนโปรแกรม (ระหว่างวันที่ 1 กรกฎาคม พ.ศ. 2545 ถึง 30 มิถุนายน พ.ศ. 2546) และ 89 คน ในช่วงหลังโปรแกรม (ระหว่างวันที่ 1 กรกฎาคม พ.ศ. 2546 ถึง 30 มิถุนายน พ.ศ. 2547) ในช่วงหลังโปรแกรมพบว่า มีอุบัติการณ์การเกิดปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจ ลดลงจาก 39.7 เหลือ 10.5 ต่อ 1000 วันของการใช้เครื่องช่วยหายใจ ($p < 0.01$) ระยะเวลาที่นอนในหอผู้ป่วยวิกฤต ระยะเวลาที่นอนในโรงพยาบาล และอัตราการตายไม่แตกต่างกันระหว่างผู้ป่วยทั้ง 2 กลุ่ม นอกจากนี้ยังพบว่าอายุ การให้ความรู้และมาตรการป้องกันปอดอักเสบที่สัมพันธ์กับใช้เครื่องช่วยหายใจมีความสัมพันธ์ต่ออุบัติการณ์นี้*

สรุป: *การให้ความรู้และมาตรการป้องกันภาวะปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจ ช่วยลดอุบัติการณ์การเกิดปอดอักเสบที่สัมพันธ์กับการใช้เครื่องช่วยหายใจ แต่ไม่มีผลต่อระยะเวลาที่นอนในหอผู้ป่วยวิกฤต ระยะเวลาที่นอนในโรงพยาบาล และอัตราการตาย*