Effect of an Education Program on the Prevention of Ventilator-Associated Pneumonia: A Multicenter Study

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Objective: *To evaluate the effect of an educational program targeted on modifiable risk factors on ventilator-associated pneumonia (VAP) rates.*
Material and Method: *After a preliminary study on VAP risk factors was conducted at one teaching hospital, a pre- and post-interventional study was then performed on 12 hospitals in Thailand from January 1, 2002 to June 30, 2003. Each hospital randomly selected 20 patients, who were on mechanical ventilation to be enrolled. The study was divided into two phases; 1) pre-intervention, 2) post-intervention. Data collected included patients' demography and risk factors for VAP. During pre-interventional phase, data on risk factors for VAP was analyzed and fedback to healthcare providers in the wards by an infection control nurse (ICN) of the individual hospital. An educational programme on the prevention of VAP was introduced by the ICN. Ventilator-associated pneumonia rates and their risk factors were continuously monitored during the post-interventionl phase.*
Results: *Two hundred and forty four patients in the pre-interventional phase and 254 patients in the post-interventional phase were included. There was no significant difference in the demography between these two patient populations. After the intervetion, there was a significant improvement in hand-hygiene practices ($p<0.001$) among healthcare providers and increased use of sucralfate ($p=0.05$) for stress ulcer prophylaxis. Ventilation-associated pneumonia rate (40.5% vs. 24%; $p<0.001$) and crude mortality rate associated with VAP (12.3% vs. 8.7%; $p<0.001$) were also reduced.*
Conclusion: *The educational programme targeted on modifiable risk factors for prevention of VAP was effective and should be considered as an intervention to reduce VAP rates in developing countries.*

Keywords: *Education, Ventilator-associated pneumonia, Risk factors, Multicenter, Intervention*

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Pneumonia is the most commonly reported nosocomial infection among adult and pediatric and neonatal intensive care unit (ICU) patients, occuring predominantly in individuals requiring mechanically ventilation, at a rate of 1-3% per day of mechanical ventilation[1-3]. In large teaching hospitals, ventilator-associated pneumonia (VAP) prevalence ranged from 10-65%, and the associated case fatality rate is over 20%[4-6]. Ventilator associated pneumonia is the most common site of nosocomial infection in adult ICU patients, accounting for up to 30% of nosocomial infection in this population[7]. Recognized risk factors for VAP can be categorized into modifiable and non-modifiable ones. Non-modifiable risk factors for VAP in adult patients include patient's age and immune status, severity of illness, levels of consciousness, prolonged ICU stay and presence of an invasive device, while modifiable risk factors include duration of mechanical

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ventilation, exposure to antibiotics, treatment with antacids or histamine type 2 receptor blockers, process of care of patients on mechanical ventilator and nursing care processes[2-3]. Increased mortality has been associated with infection attributable to *Pseudomonas aeruginosa* and *Acinetobacter* species, more severe underlying illness, and inadequate antibiotic therapy[4, 8-9]. In adult ICU, the median excess length of hospital stay (LOS) related to VAP is estimated at 7.7 days, and the attributable mortality is estimated at 10%[2-3, 7]. In addition, VAP is estimated to cost in excess of U.S. $5000 to U.S. $8000 per episode with an estimated total US cost of $1.1 billion per year in 1985[10-11].

Material and Method

A separate retrospective study was performed at one teaching hospital to evaluate the potential risk factors for VAP prior to this study. Forty patients who developed VAP were enrolled. The most frequent modifiable risk factors for developing VAP were receiving non-sucrafate medication for peptic ulcer prophylaxis (25/40; 62.5%), minimal hand-washing among

Table 1. Demographics of participants during pre- and post-interventional phases

Characteristics	Pre-interventional phase (N=244)	Post-interventional phase (N=254)
Hospital settings		
University hospital (2 hospitals)	40	45
Tertiary care hospital (5 hospitals)	106	107
General hospital (5 hospitals)	98	102
Male sex	153	168
Age (years, range)	50.8 +/- 22.1(1-81)	51.4 +/- 19.3 (5-92)

NOTE: Data are number of patients.
N=total number of participants

Table 2. Patient and healthcare provider-associated risk factors for ventilator-associated pneumonia

Patient and healthcare providers-associated risk factors	Pre-interventional phase (N=244)		Post- interventional phase (N=254)		p value
	No	%	No	%	
Position during on MV[a]	234	95.9	241	95.3	0.76
Position during feeding[a]	229	94.0	244	96.3	0.45
Change of patient position (every 2 hours)	191	78.3	204	80.5	0.90
Care of oral hygiene (2 times/day)	235	96.3	223	87.7	0.003
Handwashing Prior to manipulation of MV	127	52.0	206	81.0	<0.001
Prior to touching the patients	76	31.2	146	57.5	<0.001
Suction technique	156	63.9	192	75.9	0.02
Supine position with head elevated					
Cleaning the joints with 70% alcohol (before and after manipulation of MV)	150	61.5	205	80.7	<0.001
Presence for assitance while suctioning the patients	173	70.9	200	78.7	0.09
Wearing proper personal protective equipments					
Gloves	180	73.9	210	82.7	0.04
Mask	138	56.6	181	71.3	0.01
Correct tracheal suction technique	153	62.7	206	81.1	<0.001

NOTE: MV=mechanical ventilation with elevation of head to 30-45 degree

healthcare providers prior to the care of patients (9/40; 23%). The authors, therefore, performed a pre- and post-interventional study to evaluate the effect of an education program on VAP rates in multicentre setting.

The study was performed from January 1, 2002 to June 30, 2003. Twelve hospitals included in the present study consisted of two university, five regional and five provincial hospitals. Each hospital randomly selected 20 patients on mechanical ventilation to be enrolled. Data collection on pre-interventional phase (January 1, 2002 until August 31, 2002) included modifiable and non-modifiable risk factors for VAP. Data on risk factors for VAP during pre-interventional phase was analyzed and fedback to healthcare providers in the wards that included the patients into the study by an infection control nurse (ICN) of the individual hospital. From September 30, 2002 to October 31, 2002, an educational program on modifiable, non-modifiable risk factors and on nursing care practices as well as guidelines were given to the ward nurses. Ventilator-associated pneumonia rates and their risk factors were continuously monitored during the post-interventionl phase (November 30, 2002 to June 31, 2003) and were compared with the pre-intervention phase.

The Centers for Disease Control and Prevention/National Nosocomail infection Surveillance (NNIS) definitions were used for nosocomial infections[18]. For diagnosing VAP, the patient was required to have received for at least 48 hours of mechanical ventilation and developed new and persistent radiographic evidence of focal infiltrates. In addition, the patient should meet one of the following criteria: positive pleural/blood

Table 3. Nursing care-associated risk factors for ventilator-associated pneumonia

Nursing care-associated risk factors	Pre-interventional phase (N=244)		Post- interventional phase (N=254)		p value
	No	%	No	%	
Mechanical Ventilator (closed system)					
No routine schedule for changing condenser	145	59.6	139	54.7	0.56
Changing condenser when soaked or dirty	84	34.6	74	29.1	0.63
Mechanical Ventilator (open system)					
Changing condenser every 8 hours	176	72.1	222	87.3	0.011
Changing corrugated tubes not early than 48 hours duration	215	88.3	196	77.1	0.07
Disinfection for suction tube					
By ETO gas	121	49.6	131	51.7	0.84
Autoclaving	15	6.1	15	6.3	0.78
By disinfectants	6	2.5	8	3.0	0.69
Use disposable suction tube	**102**	**41.8**	**99**	**39.1**	**0.75**

NOTE: ETO=Ethylene oxide

Table 4. Microorganism associated with ventilator-associated pneumonia

Nursing care-associated risk factors	**Pre-interventional** phase (N=244)		**Post-interventional** phase (N=254)		*p* value
	No	%	No	%	
Acinetobacter baumannii	73	30.0	62	24.4	0.49
Pseudomonas aeruginosa	70	28.6	62	24.4	0.58
Klebsiella species	42	17.1	48	18.9	0.88
Methicillin-resistant *Staphylococcus aureus*	17	7.1	21	8.3	1.0
Others	42	17.2	61	24.1	0.35

cultures for the same organism as that recovered from the tracheal aspirate; radiographic cavitation; histopathologic evidence of pneumonia; or two of the following including fever (>38 C), leukocytosis (white blood cell >12,000/mm^3), and purulent tracheal aspirate (>25 white blood cells/high power field). Associated organisms were designated as those organisms recovered from tracheal aspirates from the patients with VAP. Crude mortality associated with VAP is defined as patient mortality occuring within 2 weeks after the development of VAP and is not attributable to other etiologies.

Data analysis was performed using SPSS Version 10.0 (SPSS, Chicago, IL). Categorical variables were compared using Chi Square Test or Fisher Exact Test, as appropriate. Continuous variables were compared using the Wilcoxon rank sum test. All *P* values were two tailed; $p<0.05$ was considered statistically significant.

Results

Two hundred and forty four and 254 patients were enrolled in the pre- and post-interventional phases respectively. One hundred and forty six participants (146/244; 60%) and 152 participants (152/254; 60%) were enrolled from university, regional, and provincial hospitals during pre- and post-interventional phase respectively. The majority of participants were from the ICU (88.5%). Demography of patients between pre- and post-interventional phase was summarized in Table 1. There was no difference with respect to patient's demography between pre- and post-interventional phases.

Compared to the pre-intervention phase, there was a significant improvement in hand-hygiene practices among healthcare providers prior to the patient care (31.2% vs. 57.5%; $p<0.001$) and prior to the care of mechanical ventilation equipment (52% vs. 81%; $p<0.001$). The use of sucralfate for stress ulcer prophylaxis also increased (2.3% vs. 2.5%; $p=0.05$). In addition, nursing care processes such as changing the mechanical ventilator condenser every eight hours (72.1% vs. 87.3%; p=0.01), wearing appropriate personal protective equipment (73.8% vs. 82.7%; $p=0.04$), and suction respiratory secretion (62.7% vs. 81.1%; $p<0.001$) were performed more often. However, care for oral hygiene (at least twice a day) was performed less often during the post-intervention phase (96.3% vs. 87.7%; $p=0.003$). There was no trend of improvement in other nursing care processes. Patient and healthcare provider-associated risk factors and important nursing care processes between pre- and post-interventional phases are compared in Tables 2 and 3.

Significant reduction in VAP rates has been demonstrated during post-intervention phase (40% vs. 20%; $p<0.001$), as well as crude mortality associated with VAP (12.3% vs. 8.7%; $p=0.05$). Ventilator-associated pneumonia was attributable to 65%, while other etiologies to 34% of mortality rates. Microbiological data revealed *Acenitobacter baumannii* (135/498; 27.1%) and *Pseudomonas aeruginosa* (132/498; 26.5%) to be the most prevalent VAP-associated microorganisms. There was no difference in microorganisms causing VAP between pre- and post-interventional phases. The data on microbiology between pre- and post-interventional phases are summarized in Table 4.

Discussion

Several patient-related risk factors have been demonstrated to be associated with VAP including intubation, duration of mechanical ventilation, aspiration, nutrition support, nasal gavage modulation of colonization, ventilator-circuit associated factors, and use of systemic antibiotics[13]. In the past, single intervention in patients undergoing intubation has focused on either reducing aspiration of oropharyngeal secretions, modulation of colonization (in oropharynx, stomach, or the whole digestive tract), use of systemic antimicrobial prophylaxis, or ventilator circuit changes. Although effective, some of these benefits must be balanced against the development of drug resistant microorganisms. Recently, multiple implemented interventions using educational programs have been used with success[14]. Therefore, in hospital settings with low baseline levels of drug resistance, the benefits to patients by using antimicrobials may outweight the fear from the development of antibiotic resistance. In Thailand, the trend of antibiotic resistance microorganisms in nosocomial settings has increased steadily for both Gram-positive and Gram-negative microorganisms[15-18]. Therefore, non-antibiotic strategies and educational programs might be most beneficial. To the authors' knowledge, the present study was the first multicenter study to demonstrate the effectiveness of an educational program targeted on modifiable risk factors for prevention of VAP in Thailand.

There are several limitations to the present study. The pre-intervention risk factors were abstracted from a single tertiary care center, these risk factors might not be generalized to all other hospitals in Thailand. The authors also did not include data on cost associated with VAP, therefore, the cost-effectiveness on the

prevention of VAP cannot be concluded from the present study. Although the study was performed in a multicenter fashion, the sample size in pre- and post-interventional phases may not be large enough to detect other relevant modifiable risk factors that might occur or may not allow us to answer the increase in prevalence of some suboptimal nursing care practices during the post-interventional phase. The post-interventional phase lasted only for eight months, thus long-term effects of the educational program cannot be evaluated from the present study. Finally, the present study only focussed on the effectiveness of the educational program, thus other interventions to reduce the occurrence of VAP cannot be drawn.

Despite these limitations, the present study suggests that the educational program targeted on modifiable risk factors is effective and practical in reducing VAP rates in Thailand. The educational program targeted on modifiable risk factors should be considered as an intervention to prevent VAP in other developing countries. Additional studies with adequte sample size and for longer duration are warranted to evaluate the effects of the educational program on the prevention of VAP rates.

Conclusion

The education program improved several practices for the prevention of VAP. The program was associated with reduction of rates of VAP and mortality associated with VAP.

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ผลของการให้การศึกษาเพื่อป้องกันปอดอักเสบในผู้ป่วยได้รับการช่วยหายใจ

สมหวัง ด่านชัยวิจิตร, อนุชา อภิสารธนารักษ์, เทพนิมิตร จุแดง, วราภรณ์ พุ่มสุวรรณ

วัตถุประสงค์ : *เพื่อประเมินผลของการให้การศึกษาแก่บุคลากรการแพทย์ เพื่อประยุกต์ใช้ในการลดปัจจัยเสี่ยงที่สามารถเปลี่ยนแปลงได้ในการป้องกันปอดอักเสบในผู้ป่วยที่ได้รับการช่วยหายใจ*

วัสดุและวิธีการ : *ประเมินปัจจัยเสี่ยงที่โรงพยาบาลแห่งหนึ่งในเบื้องต้นแล้วผู้วิจัยได้ทำการทดลองแบบก่อนและหลังการกำหนดมาตรการเพื่อป้องกันการเกิดปอดอักเสบในโรงพยาบาล 12 แห่ง ในประเทศไทยระหว่าง 1 มกราคม พ.ศ. 2545 ถึง 30 มิถุนายน พ.ศ. 2546 แต่ละโรงพยาบาลเลือกผู้ป่วยแบบสุ่มจำนวน 20 คน ที่ได้รับเครื่องช่วยหายใจมาเข้าร่วมทดลอง โครงการวิจัยแบ่งเป็น 2 ช่วง คือ ช่วงก่อนทดลอง และช่วงหลังทดลอง โดยผู้วิจัยได้เก็บข้อมูลเกี่ยวกับผู้ป่วยและปัจจัยเสี่ยงต่อการเกิดปอดอักเสบหลังจากการได้รับเครื่องช่วยหายใจ นำเสนอข้อมูลปัจจัยเสี่ยงในช่วงก่อนการทดลองแก่ผู้ร่วมวิจัย โดยพยาบาลควบคุมโรคติดเชื้อในแต่ละโรงพยาบาล จากนั้นจึงให้การอบรมความรู้เกี่ยวกับปัจจัยเสี่ยงที่เปลี่ยนแปลงให้แก่ผู้ร่วมวิจัยในช่วงทดลอง ติดตามการปฏิบัติ และอัตราการเกิดปอดอักเสบในผู้ป่วยที่ได้รับเครื่องช่วยหายใจ ในระยะหลังการกำหนดมาตรการ*

ผลการศึกษา : *ผู้ป่วย 244 คน เข้าโครงการวิจัยในช่วงก่อนการทดลอง และ 254 คน ในช่วงหลังการทดลอง ไม่มีความแตกต่างอย่างมีนัยสำคัญ ระหว่างผู้ป่วยทั้ง 2 กลุ่มนี้ หลังการให้การศึกษาพบว่ามีการล้างมือในกลุ่มบุคลากรเพิ่มขึ้นอย่างมีนัยสำคัญ ($p<0.001$) และยังพบการเพิ่มของการใช้ยาป้องกันการเกิดแผลในกระเพาะด้วยยา sucralfate ($p=0.05$) ปอดอักเสบในผู้ป่วยที่ได้รับเครื่องช่วยหายใจมีอุบัติการณ์ลดลง (40.5% vs.24%; $p<0.001$) อัตราการตายจากปอดบวมก็มีอัตราลดลง ($p<0.001$)*

สรุป : *ข้อมูลจากการวิจัยนี้สนับสนุนประสิทธิผลของการให้การศึกษาเพื่อประยุกต์ใช้ในการลดปัจจัยเสี่ยงที่สามารถเปลี่ยนแปลงได้ในกลุ่มผู้ดูแลผู้ป่วยที่ได้รับเครื่องช่วยหายใจและทำให้อัตราป่วย, อัตราป่วย-ตายลดลง*