# VENTILATOR-ASSOCIATED PNEUMONIA (VAP) IN INTENSIVE CARE UNIT: THE ROLE OF VAP BUNDLE EDUCATION IN REDUCING ITS RATES

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Introduction: Awareness and knowledge are important aspects of VAP prevention program. The participants have fair knowledge in VAP and VAP prevention. However, being knowledgeable does not assure implementation of evidence-based guideline, and guidelines adherence require the readiness to sustain that changed behavior.

Objective: Study objective is to determine the effect of VAP-bundle educational program on nurses' knowledge, practice, and incidence rate as well as factors associated with ventilator-associated pneumonia in ICU.

Materials and methods: A prospective study on VAP was conducted in ICU with two study groups, ICU nurses and patients who are ventilated for 48 hours or more. Nurses who consented were subjected to self-administered questionnaire before and after VAP-bundle educational program. While patient's data before and after was collected from their medical records from early 2009 to early 2011. VAP was diagnosed based on Central for Disease Control and Prevention (CDC). The

definition used for diagnosis was based on clinical and organisms isolated from tracheal aspirate.

Result and discussion: Pre and post-intervention mean and standard deviation of participants score were fair but were significant different pre compared to post-intervention, [56.11 (2.82), 62.19 (2.70), mean score difference: 6.07 (4.95, 7.20) 95% *CI, p* < 0.001] respectively. Meanwhile the pre-intervention VAP rates were found to be reduced from 17.3 episodes per 1,000 ventilator-days to 7.0 episodes per 1,000 ventilator-days. The reduction rate was 59.5% but no significant association with VAP bundle interventions. It is associated with increased of the nurses' skills in delivering of care related to oral care practices, maintaining of endotracheal tube cuff pressure, performing meticulous hands hygiene and infection control. After adjusting for cofounder, multiple logistic regression revealed that patients who undergo intrahospital transport are 7.2 times at risk to develop VAP compared to non-transport patients [Adjusted OR: 7.2, 95% *CI:* 2.46, 21.28, *p* < 0.001]. The main reasons for intrahospital transport were computed tomography scanning, and surgery. Meanwhile patients who have renal insufficiency are 5.7 times at risk to develop VAP [Adjusted OR: 5.7, 95% *CI:* 1.77, 18.84, *p* = 0.004]. Hortal et al*.* (2009) reported that patients who have creatinine levels of > 1.5 mg/dl were at risk to develop VAP. It is crucial to provide regular continuous nursing education program for at least 3-4 times a year to increase nurses' awareness and knowledge on VAP prevention strategies. It is essential to explore the factors that contribute to the development of VAP for patients who have renal insufficiency and undergo intrahospital transportation in the ICU.

Conclusion: There were significant reductions in VAP rate after intervention period. However the nurses' knowledge on VAP and the prevention strategies were inadequate. Intrahospital transport and patient with renal insufficiency are more at risk to develop VAP.

Keywords: nurses' knowledge, ventilator-associated pneumonia, rate of ventilator-associated pneumonia, intrahospital transport, and renal insufficiency

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**by**

**ZAHNIYAH BINTI CHE ISHAK**

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## LIST OF ABBREVIATIONS

ARDS: acute respiratory distress syndrome

BAL: bronchoalveolar lavage

CDC: Central of Disease Control and Prevention

CHG: chlorhexidine gluconate

COPD: chronic obstructive pulmonary disease

CPIS: Clinical pulmonary infection score

DSS decision support system

DVT: deep venous thrombosis

ETT: endotracheal tube

EBP: evidence-based practices

Fi $O_2$: fractional oxygen

HAP: hospital acquired pneumonia

HAI: hospital acquired infection

HCAI: Healthcare-associated infection

HME: heat-moisture exchanger

HOB: head-of-bed

HOBE: head-of-bed elevation

HLOS hospital length of stay

$H_2$RA: histimine-2 receptor antagonist

HUSM: Hospital Universiti Sains Malaysia

ICU: Intensive Care Unit

IqR: Interquartile range

IHT: intrahospital transport

LMWH: low molecular weight heparin

LOS: length of stay

mV: minute volume

NG: nasogastric tube

NGF: nasogastric tube feeding

PDA: personal digital assistants

PPI: proton pump inhibitor

PSB: protected specimen brush

PTSD post traumatic syndrome disorder

RCT: randomized control trial

RR: respiration rate

$SaO_2$: saturation oxygen

SDD: subglottic secretion drainage

SUP: stress ulcer prophylaxis

TV: tidal volume

UFH: unfractionated heparin

VAP: ventilator-associated pneumonia

## *VENTILATOR-ASSOCIATED PNEUMONIA* (VAP) DI UNIT RAWATAN INTENSIF: PERANAN PENDIDIKAN VAP *BUNDLE* DALAM MENGURANGKAN KADARNYA


### ABSTRAK

Pengenalan: Kesedaran dan pengetahuan adalah aspek penting dalam program pencegahan VAP. Pengetahuan peserta kajian tentang VAP dan pencegahannya adalah sederhana. Walaubagaimanapun, pengetahuan tidak memastikan amalan mengikut garispanduan saintifik dan implementasi garispanduan memerlukan perubahan dan kelestarian.

Objektif kajian: Memastikan kesan program pendidikan VAP *bundle* ke atas pengetahuan serta amalan jururawat dan kadar insiden serta faktor yang berkaitan dengan VAP di ICU.

Bahan dan kaedah kajian: Kajian prospektif dijalankan di ICU dengan dua kumpulan kajian, jururawat ICU dan pesakit yang menerima bantuan pernafasan 48 jam atau lebih. Jururawat dalam kajian dikehendaki mengisi borang soal selidik sebelum dan selepas program pendidikan VAP *bundle*. Data pesakit diambil dari rekod perubatan pesakit sebelum dan selepas program pendidikan VAP *bundle* pada awal tahun 2009 sehingga awal tahun 2011. Definisi VAP adalah dirujuk dari Central for Disease Control and Prevention (CDC). *Diagnosis* VAP yang digunakan dalam kajian adalah pengesahkan klinikal dan organisma dari aspirasi trakea.

Keputusan kajian dan perbincangan: Skor min sebelum dan selepas serta sisihan piawai peserta adalah sederhana, tetapi terdapat perbezaan yang signifikan jika dibandingkan di antara sebelum dengan selepas program

pendidikan VAP *bundle* [56.11(2.82), 62.19 (2.70), perbezaan skor min: 6.07 (4.95, 7.20) *CI*: 95% $p < 0.001$] mengikut urutan. Walaubagaimanapun, skor ini adalah lebih rendah berbanding peratus jawapan betul bagi hospital di Thailand, sebelum [62.19, SD: 2.72] dan selepas [78.5%, SD: 10.2%] (Apisarnthanarak et al., 2007), tetapi jauh lebih tinggi berbanding hospital di Ghent 41.2% (Blot, Labeau, Vandijck, Van Aken & Clae, 2007). Kadar VAP berkurangan selepas intervensi iaitu daripada 17.3 episod setiap 1,000 hari-*ventilator* kepada 7.0 episod setiap 1,000 hari-*ventilator* selepas intervensi. Penurunan kadar VAP adalah sebanyak 59.5% tetapi tidak signifikan dan tidak berkaitan dengan intervensi VAP *bundle*. Hal ini adalah berkaitan dengan peningkatan kemahiran jururawat dalam memberi perawatan berkaitan dengan penjagaan oral, pemantauan kuf tiub endotrakea, cucian tangan dan pengawalan jangkitan. Selepas penyelarasan terhadap faktor menganggu (*cofounder)* regresi logistik pelbagai membuktikan pesakit ICU yang di *transport intrahospital* adalah 7.2 kali ganda berisiko mendapat VAP berbanding pesakit yang tidak. Sebab utama pesakit yang perlukan *transport intrahospital* adalah untuk menjalani skan tomografi berkomputer dan pembedahan. Bukti ini selaras dengan kajian oleh Kollef *et al.* (1997) dan Bercaualt et al. (2005). Manakala pesakit yang ada masalah *renal insufficiency* adalah 5.7 berisiko mendapat VAP [Adjusted OR: 5.7, 95% *CI:* 1.77, 18.84, $p = 0.004$]. Hortal et al. (2009) melaporkan bahawa pesakit yang mempunyai serum kretinin > 1.5 mg/dl berisiko mendapat VAP. Menambahkan bilangan program pendidikan kejururawatan sekurang-kurangnya 3-4 kali setahun bagi meningkatkan

kesedaran dan pengetahuan jururawat tentang strategi pencegahan VAP adalah perkara paling utama yang perlu dititik beratkan. Satu kajian juga diperlukan untuk meneroka faktor penyumbang terhadap VAP dalam kalangan pesakit di ICU yang mengalami *renal insufficiency dan* pesakit yang perlukan *transport intrahospital* di ICU.

Kesimpulan: Pengetahuan jururawat tentang VAP dan strategi pencegahannya adalah tidak mencukupi. Penurunan kadar VAP adalah 59.9%, iaitu dari 17.3 kepada 7 episodes per 1,000 hari-*ventilator*. Pesakit di ICU yang menjalani *transport intrahospital* dan pesakit yang mempunyai masalah *renal insufficiency* adalah berisiko mendapat VAP berbanding dengan pesakit lain

Kata kunci: pengetahuan jururawat, *ventilator-associated pneumonia*, kadar *ventilator-associated pneumonia*, *transport intrahospital*, *renal insufficiency*.

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Conclusion: There were significant reductions in VAP rate after intervention period. However the nurses' knowledge on VAP and the prevention strategies were inadequate. Intrahospital transport and patient with renal insufficiency are more at risk to develop VAP.

Keywords: nurses' knowledge, ventilator-associated pneumonia, rate of ventilator-associated pneumonia, intrahospital transport, and renal insufficiency.

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

### 1.1.1 Epidemiology of Ventilator-associated pneumonia

Ventilator-associated pneumonia (VAP) is a common healthcare-associated infection (HCAI) among patient receiving mechanical ventilation in Intensive Care Unit (ICU). VAP rate varies from site to site and related to the duration of mechanical ventilation. The VAP rate differs from countries to countries ranging from 8-28%. In the developed country the VAP rate was lower (Tablan, Anderson, Besser et al*.,* 2004; Chastre & Fagon, 2002). Whilst VAP rate in Asian countries like Singapore, and Malaysia teaching hospital is 21.4% (Hughes, Norliza, Tan et al*.*, 2004). In Thailand, the VAP rate was 40% (Danchaivijitr, Assanasen, Apisamthanark et al*.*, 2005). In our ICU, unpublished VAP rate is approximately 10-20% (ICU surveillance, 2006; ICU surveillance, 2007), and similar globally [10-25%] (Mayhall, 2007; Jarvis, 2007). Researchers found that VAP increases morbidity mortality; costs of hospitalization, duration of stay and causes physical and mental suffering to patients and their families (Cook, 2000 Park, 2005; Pruitt & Jacobs, 2006; Ruffell & Admavoca, 2008). Patients' with underlying factors such as elderly, malnutrition, diabetes, renal insufficiency, and chronic obstructive pulmonary disease (COPD) are prone to get VAP due to defense mechanisms impairment. Poor infection control technique among health

care workers could influence the outcome of patients with VAP. In order to prevent VAP, education of healthcare workers is important. Education had been identified to be the key component in preventing VAP. This is due to nurses are the main care givers in ICU. Therefore it is crucial to equip them with the knowledge in VAP prevention. Danchaivijitr et al. (2005) in a multicenter study found that educational program reduces VAP rate by 50% thus effectively reduces costs and patient morbidity. Education, motivation and giving rewards to staff have also been shown to be a crucial part of VAP prevention strategies (Danchaivijitr et al., 2005; Cason, Tyner, Saunders et al., 2007; Huang & Wu, 2008). Many HCAI prevention guidelines exist (CDC, 2009; SARI Working Group, 2011; Smiths Medical North America, 2009). However, being knowledgeable does not mean healthcare workers could abide to the recommendations (Jarvis, 2007). The VAP bundle is the recommended intervention used in preventing VAP. VAP bundle is a group of evidence-based practices that, when implemented for all patients on mechanical ventilation, results in tremendous reductions in the incidence of VAP (Institute of Healthcare Improvement, 2006). Most of the evidence-based practices such as VAP bundle consist of semi-recumbent position, sedation vacation and daily assessment, stress ulcer prophylaxis and deep vein thrombosis prophylaxis (Youngquist, Carrol, Farber et al., 2007; Westwell, 2008). Practice of infection control by the health care workers also helps in the prevention of VAP (Youngquist et al., 2007; Westwell, 2008).

## 1.2 **Problem Statement**

VAP bundle had been adopted for more than one year in the ICU, Hospital Universiti Sains Malaysia. However, the rates remained at 10-20% (ICU surveillance, 2006; ICU surveillance, 2007) for two years. This shows that there are gaps between the actual standard of care and practice. The same evidence is also reported by Sierra, Benitez, Leon et al. 2005. Many countries had adopted VAP bundle concept in the management of VAP and had targeted zero tolerance. VAP bundle concept needs to be highlighted and emphasized in order to enhance care workers knowledge and practices and the need for culture change while delivering care to the ventilated patient to prevent VAP.

## 1.3 **Operational definition**

### 1.3.1 **Ventilator-associated Pneumonia**

VAP is defined as an inflammation of the lung parenchyma caused by infectious agents not present or is incubating when mechanical ventilation began. CDC (2009) defines VAP as a new and persistent infiltrate on chest radiography with at least two of the following three criteria, i. fever > 38$^{o}$C, or ii. leukopenia (< 4000 WBC/mm$^{3}$) or leukocytosis (> 12,000 WBC/mm$^{3}$; and iii. purulent tracheal secretions and, an organism isolated from trachea aspirate or bronchoalveolar lavage (BAL) and/or organism isolated from blood specimen (Keeley, 2007; CDC, 2009).

### 1.3.2 **Sedation vacation**

Sedation vacation is a process in which patient sedation is interrupted until the patient follows commands and patient is assessed for discontinuations of mechanical ventilation (Institute of Healthcare Improvement, 2006). Sedation is withheld daily and neurological assessment is made to the patients.

### 1.3.3 **Ventilator-associated Pneumonia Bundle**

Ventilator-associated pneumonia bundle is a group of evidence-based practices that when implemented for all of the patients on mechanical ventilator results in significant reduction in the incidences of VAP (Gillespie, 2007). The theory hypothesis is, the VAP bundles improves ventilated patients outcome, in terms of shortening ventilator days, duration length of Intensive Care Unit stays, hence preventing the occurrence of VAP. Therefore a few of the evidence-based interventions are used together in a single protocol which may provide the best outcome in the VAP prevention strategies (Gillespie, 2007). The VAP bundle includes semirecumbent position of 30-45$^{o}$, sedation vacations and daily assessment, stress ulcer prophylaxis, deep venous thrombosis prophylaxis and infection control.

### 1.3.4 **Oral care**

Oral care consists primarily of a mouth rinse, possessing cleansing (include toothbrushing, removing and oral suctioning), germicidal, or palliative properties (Medical Dictionary, 2007).

### 1.3.5 **Proteinaceous**

Proteinaceous is pertaining to or of the nature of protein (Medical Dictionary, 2007) material.

### 1.3.6 **Nosocomial infection**

The terms ‘‘nosocomial infections‘‘ is replaced by ‘‘healthcare-associated infections’’ (HCAIs), to reflect the changing patterns in health care delivery and difficulty in determining the geographic site of exposure to an infectious agent and/or acquisition of infection (Siegel, Rhinehart, Jackson et al., 2007).

### 1.3.7 **Educational program**

The educational program used in the study was modified from the CDC guidelines. The program was implemented to the nurses in ICU. Four topics were chosen. The lectures were delivered by anesthesiologist, a lecturer from the Department of Microbiology, a senior staff from the infection control unit (UKJEH) and the study investigator. The lecture topics include introduction to body flora, epidemiology of VAP, the ventilator bundle, and infection control practices related to the prevention

of VAP (Tablan et al., 2004; Coffin, Klompas, Classen et al., 2008). Infection control practices topics were on standard universal precautions including hand hygiene.

### 1.3.8 **Healthcare-associated infection**

Healthcare-associated infection is an infection that patients obtain while receiving medical management for other illnesses within a healthcare setting (Smiths Medical North America, 2009).

## 1.4 **OBJECTIVES**

### 1.4.1 **General objective**

The aim of the study is to determine the effect of an educational program of VAP bundle on the knowledge and practice among nurses in ICU.

### 1.4.2 **Specific objectives**

1.4.2(a) To determine the rate of VAP before and after VAP bundle educational program.

1.4.2(b) To evaluate the level of knowledge among nurses on Ventilator-Associated Pneumonia (VAP) before and after VAP bundle educational program.

1.4.2(c) To determine the risk factors associated with VAP.

## 1.5 **Research questions**

1.5.1 What is the nurses' level of knowledge on VAP before and after the VAP bundle educational program?

1.5.2 What is the incidence of VAP before and after the VAP-bundle educational program?

1.5.3 What is the difference between the nurses' knowledge before and after participating in VAP-bundle education program?

1.5.4 What are the associated risk factors of VAP?

## 1.6 **Hypothesis**

| | |
|---|---|
| Hypothesis Null: | There are no significant differences of knowledge before and after participating in the VAP bundle educational program |
| Directional Hypothesis Alternative: | There are significant increase in nurses knowledge after participating in the VAP bundle educational program |
| Hypothesis Null: | There are no significant differences of VAP rate before and after the VAP bundle educational program |
| Directional Hypothesis Alternative: | There are significant reduction of VAP rate after the VAP bundle educational program |
| Hypothesis Null: | There are no significant association between risk factors and VAP. |
| Directional Hypothesis Alternative: | There are significant association between risk factors and VAP |

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

Ventilator-associated pneumonia (VAP) is a common healthcare-associated infection (HCAI) in ICU. Guidelines on prevention and standard operative procedure are necessary to reduce the VAP rates. The approaches to prevention strategies in ICU should be multifaceted and multidisciplinary (Craven & Duncan, 2006). Awareness and knowledge on prevention strategies are crucial to bridge the gap between practice and evidence-based. Nurses are core healthcare workers and they are accountable in the delivering care. It is crucial for them to have relevant knowledge on the epidemiology of VAP, its pathogenesis, the local VAP rates, risk factors, and prevention strategies. This literature review focuses on the conceptual framework of the study, nurses' knowledge and the causes, risk factors and prevention strategies of VAP. It also includes the epidemiology, pathogenesis, and types of VAP; the roles of education program, and prevention strategies. VAP bundle are used as the preventive strategies which is the standard of care. These strategies include prevention of aspiration, reducing numbers of organism in the oropharyngeal cavity by performing oral care with chlorhexidine, meticulous hand hygiene, and ventilator care.

## 2.2 **Ventilator-associated pneumonia**

HCAIs are common complications in healthcare facilities worldwide (Jarvis, 2007). VAP is one of the most troublesome healthcare-associated infections (HCAI) which occurs 48 hours or more in a patient who is hooked on mechanical ventilator (Chastre, 2005). VAP was defined as changes of patient chest radiograph from normal at baseline to infiltrate, consolidation, cavitation, or pleural effusion with one of the following: fever > 38$^{o}$C, or leukopenia (< 4000 WBC/mm$^{3}$) or leukocytosis (> 12,000 WBC/mm$^{3}$) or for adults > 70 years old, altered mental status and at least two of the following: change of patient respiratory secretion from normal to purulent or increased respiratory secretions or increased suctioning requirements, new onset or worsening cough or dyspnea, or tachypnea, rales or bronchial breath sounds, worsening gas exchange (e.g. $O_2$ desaturations, e.g., $PaO_2/FiO_2$ < 240), increased oxygen requirements, or increased ventilator demand, and an organism isolated from trachea aspirate or bronchoalveolar lavage (BAL), or organism isolated from blood specimen (Centers for Disease Control and Prevention, 2009).

Accurate data on the epidemiology of VAP which are limited by the lack of standardized criteria for its diagnosis and absence of a “gold standard” continue to enhance controversy about the adequacy and relevance of many studies in this field (Cook, 2000; Chastre & Fargo, 2002; Klompas, 2010).

Pneumonia diagnosis is not simple (Alp & Voss, 2006; Schurink, van Nieuwenhoven, Jacobs et al., 2004). We may be over or under-diagnose pneumonia. There have been disagreements regarding pneumonia diagnosis. Diagnosis based on a radiographic infiltrate and one clinical feature alone is sensitive but not specific. Therefore cultures of lower respiratory tract secretions were suggested to be included (Wunderink, 2000; Centers for Disease Control and Prevention (CDC), 2009). In addition, a bronchoalveolar lavage (BAL) or protected specimen brush (PSB) with quantitative analysis may be more specific but not practical. Besides, invasive diagnostic techniques for BAL and PSB, and quantitative analysis of microbiological culture, are recommended and might be able to differentiate between colonization and infection of the respiratory tract (Soto, 2007). On the other hand, bronchoscopy is risky and quantitative culture is costly and time consuming (Schurink, Visscher, Lucas et al., 2007; Schurink et al., 2004). Therefore invasive diagnostic techniques for BAL and PSB are not practical. These techniques are usually implemented during the study period and remain unused after the completion of the study. As a result, these techniques have not yet become common practice in most ICUs (Schurink et al., 2007). Endotracheal aspirate or sputum and/or blood isolate is necessary to confirm pneumonia diagnosis and is the common practice in Hospital in Malaysia. BAL and PSB are rarely used for routine diagnostic test of suspected pneumonia cases due to the complication and additional costs.

Up to this present moment there is no gold-standard to diagnose pneumonia in ventilated patients (Alp & Voss, 2006). Diagnosis based on a radiographic infiltrates and one clinical presentation alone may increase antibiotic resistant microorganism due to over-diagnose pneumonia. Management of unconfirmed pneumonia case could expose the pneumonia patients to antibiotic resistant microorganism. A normal practice is to use a broad spectrum antibiotic to cover both Gram negative and Gram positive organisms. However, sometimes it is not specific and sensitive to the underlying organism. To overcome this problem, a handheld computers, or personal digital assistants (PDAs) could assist in VAP diagnosis and choosing correct antibiotic for each patient. Trusted evidence-based guidelines are available online and PDAs is small and useful, and have been used widely. Sintchenko and co-workers study the decision support system (DSS) in confirmation of VAP diagnosis and choosing correct antibiotic therapy. The criteria used for VAP diagnosis in the study by Sintchenko et al. (2004) are DSS and Clinical Pulmonary Infection Score (CPIS) plus microbiology report. He found that DSS improved patient's management and outcome. He also compared the decision made by physicians using DSS (intervention group) with the decision of an expert's panel based on diagnosis and management of VAP (control group). He found that the decisions made by the physicians are in accord with the decisions of an expert panel from 65% to 97% ($p$ = 0.0002) (Sintchenko et al., 2004). This type of system might be expensive but it could save life as well as healthcare costs.

Fever sometimes maybe an inflammation responds of other pathology than pneumonia in critical the ill patients in ICU. Alveolar infiltrate in patients chest radiograph might be due to acute respiratory distress syndrome and or atelectasis (Sharma, Maycher & Eschun, 2007; Wunderink, 1992). Likewise, it is necessary to confirm pneumonia diagnosis with sputum and/or blood isolate (Wunderink, 2000; CDC, 2009). When facing with difficulty in confirming VAP it is advisable to do at least two or serial chest radiography as repeated chest radiographs sometimes had support to the confirmation of pneumonia cases (CDC, 2009).

Multiple episodes of healthcare-associated pneumonia may arise in critically ill patients especially in those with prolonged length of stays. When deciding whether to report multiple episodes of healthcare-associated pneumonia in a single patient, the proof of resolved in infection for each episode must be determined. The additional change in microorganism cultured alone is not indicative on a new episode of pneumonia. New diagnosis of pneumonia including HAP or VAP must be based on new clinical manifestation of pneumonia together with chest radiographic confirmation or with other diagnostic test (CDC, 2009).

The radiographic criteria used to diagnose VAP rely on subjective interpretations of lung parenchyma changes that might be too little, short-lived and complicated to differentiate in an ICU patient. These opacities often do not follow typical anatomic distribution and are often masked by

pleural effusions, atelectasis, pulmonary oedema, or postoperative changes (Halpern, Hale, Sepkowitz et al., 2012). Therefore experts are required to analyze patient's chest radiograph to confirm diagnosis especially in difficult cases.

Pneumonia may have a brisk onset and development, but are slow in resolving. Therefore the pneumonic changes on chest radiograph may be delayed in resolving too, sometimes up to few weeks. Therefore, rapid radiographic resolution may suggest that the patient does not have pneumonia, but perhaps a non-infectious process such as atelectasis or congestive heart failure. The radiographic pneumonic changes can be described in diverse of way such as "air-space disease", "focal opacification", or "patchy areas of increased density". Although perhaps these are not specifically delineated as pneumonia by the radiologist, in the appropriate clinical setting these alternative descriptive wordings should be seriously considered as potentially positive findings (CDC, 2009).

If there are doubts even after the serial chest radiograph, a computed tomography should be opted for as it is mandatory in unresolved cases (Sharma et al., 2007). Over-diagnose pneumonia may expose patient to unnecessary antibiotic usage which is equivalent to cost, increase multidrug resistance organism, and increase in length of stay (Alp & Voss, 2006).

Therefore ICU nurses should have knowledge on pneumonia criteria to be able to identify VAP and justify the prescribed antibiotic. Invasive ventilation, (Tablan et al., 2004) and accidental extubation or reintubation ought to be avoided (Epstein, 2002) to prevent VAP.

Patients who are confirmed to be extubated must pass breathing trial which is designed to assess for upper airway obstruction, secretion volume, and the effectiveness of cough. Consequently, delay in reestablishing ventilator support after a fail extubation is associated with increased mortality. Healthcare workers have to be alert to any slight changes from their patient to anticipate extubation failure (Epstein, 2002).

Drugs are commonly administered in ICU to relieve anxiety and pain, such as sedative and analgesic (Mehta, Burry, Fischer et al., 2006). Analgesia administration for post-operative patient who are on sedation vacation is essential to prevent discomfort and restlessness, which could lead to unintentional extubation (Epstein, 2002). Discomfort may lead to restlessness and could result in unsecure endotracheal tube and dislodgment of the tube (self-extubation or accidental extubation). The endotracheal tube which is inserted into the patient's trachea is connected to a mechanical ventilator to assist and support patient's ventilation. Therefore a dislodgment of the endotracheal tube could be fatal to the mechanical ventilated ICU patients and should be avoided.

Extubation failure is associated with a poor prognosis usually follow an obvious decline in patient's clinical presentation. Indeed, if it is clear that reintubation is necessary (Thille, Harrois, Schortgen et al., 2011), if possible non-invasive ventilation may be the mode of choice (Alp & Voss, 2006).

A study reported that the rates for reintubation were 18% 26 out of 168 planned extubation required reintubation within 72 hours and another four patients required reintubation after 72 hours. The reasons for reintubation include acute respiratory failure [*n* = 19, 73%], coma [*n* = 4, 15%], and shock [*n* = 3, 12%] (Thille et al., 2011).

VAP rate varies from one location to another, and is related to the duration of mechanical ventilation. Longer duration of mechanical ventilator is proportional to higher VAP incidence rate. VAP rates among ICU patients differ from study to study i.e. 8-28%; 10-25%, 10-20% and 15%, (Chastre & Fagon, 2002; Mayhall, 2007; Jarvis, 2007; Safdar, Crnich & Maki, 2005a; Tablan et al., 2004) respectively. Most researchers found that their VAP rates is approximately 10-20% (Mayhall, 2007; Jarvis, 2007; Safdar et al., 2005a; Tablan et al., 2004) as opposed to a multicenter study in Thailand which reported a higher VAP rates of 40% (Danchaivijitr et al., 2005). VAP rates are lower in developed countries compared to developing counties. Much has been debated regarding achieving zero tolerance of VAP rates. All clinician involved in delivering care to patients in ICU should have access to their

local VAP rates to ensure that they understand what the data means to their local situations.

## 2.3 **Pathogenesis**

Understanding the pathogenesis of VAP is crucial in the prevention strategies. The pathogenesis of VAP is multifactorial (Bassi & Torres, 2011). VAP may occur by four ways: haematogenous spread from a local infection; contiguous spread; inhalation of infectious aerosols, ventilators from nebulizers, respiratory equipment, and aspiration from gastric colonization, oropharyngeal secretion, gastro-esophageal reflux and enteral feeding (Kim, Koziol-Mclain, Wilson et al., 2007; Alp & Voss, 2006). Pathogen colonization in oropharynx and gastrointestinal tract are the main source of aspirates (Paju & Scannapieco, 2007; Augustyn, 2007; Safdar, Crnich & Maki, 2005b).

Oral bacteria, poor oral hygiene, and periodontitis could influence the VAP rate (Paju & Scannapieco, 2007). Endotracheal intubation is prerequisite for the development to VAP (Bonten, Kollef & Hall, 2004). It causes impairment to the pulmonary defense mechanisms, therefore endotracheal intubation and mechanical ventilation should be avoided (Tablan et al., 2004) whenever possible. Non-invasive positive-pressure ventilation with facial mask could be used instead (Tablan et al., 2004). Endotracheal tube will provide a direct route for oxygen along with organisms to enter the lungs. The normal function of the upper respiratory tract is as physical and mechanical barrier in concert with the

gastric acid as a chemical barrier (Fahy & Dickey, 2010) to protect the lungs from organisms and dusts. The air which enters the nose is warm and moist before entering the lungs (Voynow & Rubin, 2009). Endotracheal tube will push away the normal defense system and patients are susceptible to VAP. Once VAP sets in, it could lead to septicemia and increase morbidity and mortality. VAP is a burden to the healthcare workers, patients and their families. VAP is divided into two types which are weighed by the durations of mechanical ventilation. The write-up below is on the description of the two types of VAP.

## 2.4 **Types of ventilator-associated pneumonia**

Determining the type of VAP can help identify the causative organism thus, guide antibiotic therapy (Pruitt & Jacobs, 2008). VAP is divided into two types, the early-onset VAP or type 1 and the late-onset or type 2. Distinguishing the types of VAP is essential since the early-onset has better prognosis compares to the late-onset. This is because the causative organism in late onset usually more resistant to certain antibiotics. The responsible organisms of the early-onset VAP is often the same as the community-acquired pneumonia (CAP). These organisms usually are *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella pneumonia* (Pruitt & Jacobs, 2008). The early-onset VAP occurs during the first four days of mechanical ventilation and this organism is easily treated and easily identified compared to these of the late-onset VAP (Davies, 2009; Keeley, 2007).

The late-onset VAP occurs five days or more after the start of mechanical ventilation. It is a healthcare acquired infection and the common organisms are *Staphylococcus aureus, Acinetobacter baumanii, Pseudomonas aeruginosa, Klebsiella pneumoniae and Entrobacter species* (Pruitt & Jacobs, 2008). These are well known pathogens and are multi-drug resistant organism and require specific antibiotics, thus they have grave prognosis compared to the early-onset. VAP is divided into two types for ease of identification of caustic organisms and antibiotic therapy. The VAP risk factors will be discussed in the next subheading.

## 2.5 **Risk Factors of ventilator-associated pneumonia**

Identifying risk factors for VAP is vital in its prevention strategies. Risk factors provide information about the chance of lung infection developing in individuals and population. Thus, knowing the risk factor could aid and support healthcare workers in the prevention strategies against pneumonia (Chastre & Fargon, 2002). Patient who developed VAP have certain risk factors (Davies, 2009; Schleder, Stott & Lloyd, 2002), such as conditions that increase the risk of colonization by pathogens in the oral cavity and previous antibiotic therapy (Chlebicki & Safdar, 2007; Schleder et al., 2002). These critically ill patients with the underlying risk factors are more susceptible than other patients.

## 2.6 **Implication of ventilator-associated pneumonia**

### 2.6.1 **Morbidity**

VAP has implication on morbidity and mortality. VAP causes prolonged ventilation duration, increases length of stay in ICU and hospital, psychological sufferings to patient (Tejerina, Frutos-Vivar, Restrepo et al., 2006; Chavez, Delahanty, Cahill, et al*.,* 2005; Myhren, Tøien, Karlsson et al., 2009) and family. ICU patients are (1:10) at risk for developing post traumatic syndrome disorder (PTSD). The PTSD could be reduced with changes within the ICU and patient support after ICU discharge (Jones, Bäckman, Capuzzo et al., 2007). VAP is associated with prolonged length of stay which increases burden on health care resources (Rotstein, Evans, Born et al., 2008).

Contribution of VAP to mortality has been a controversial subject. Researchers found that mortality is related to underlying and severity of the disease (Nguile-Makao, Zahar, Francais et al*.*, 2010; Bonten et al., 2004; Rello, Jubert, Vallés et al., 1996). VAP is associated with mortality equally amongst patients with shock, acute renal failure, and worsening hypoxemia during ventilation period (Tejerina et al., 2006). However, at least one systemic review has shown that VAP is not related to in trauma and acute respiratory distress syndrome cases (Melsen, Rovers & Bonten, 2008). VAP could lead to bacteremia, septic shock, sepsis pleural effusion, and multi-organ failure (Narang, 2008), VAP is a continuous threat to mechanical ventilated patients if the vicious cycle chain could not be broken (Dodek, Keenan, Cook et al., 2004).

In order to reduce VAP rate, continuous educational program is necessary and potent tool in any prevention strategies for VAP (Cason et al., 2007; Danchaivijitr et al., 2005; Tablan et al., 2004).

### 2.6.2 **Prevention**

An important risk factor in VAP patient is the risk of aspiration. Conditions that increase the risk of aspiration that has been discuss repeatedly are being in supine position (Apisarnthanarak, Pinitchai, Thonghubethe et al., 2007; Metheny, Clouse, Chang et al., 2006), distended abdomen or gastric over distension, bacterial colonization in the upper airway and stomach (Burns, 2007; Paju & Scannapieco, 2007), history of stress ulcer and stress ulcers, nasotracheal intubation, decreased level of consciousness, and poor maintenance of endotracheal cuff pressure (Cook, Attia, Weaver et al., 2000a), presence of a nasogastric tube (NGT) (Apisarnthanarak et al., 2007), and endotracheal intubation (Schleder et al., 2002). The presence of tubes in the airway such as ETT and NGT interferes in cough and swallowing mechanisms and often leads to aspiration and ultimately VAP (Trieger, 2004). Patients own intrinsic factors such as extreme age, malnutrition, diabetes, renal insufficiency and, chronic obstructive pulmonary disease (COPD) (Aspisarunthanarak et al., 2007) will impair defense mechanisms. At least one study identify trauma and male gender are also risk factors for VAP (Metheny, Schallom, Oliver et al.,

2008). Severe trauma patients are most likely need longer duration of stay in ICU due to head injury and internal organ injury. Most researchers have identified that poor infection control techniques by healthcare workers contribute to VAP (Pruitt & Jacobs, 2006; Tablan et al., 2004). Ineffective hand hygiene and using ungloved hands while managing the respiratory secretions or equipment soiled with respiratory secretions also lead to VAP (Pruitt & Jacobs, 2006). Meanwhile, sucralfate used were associated with an increased risk of VAP during ARDS (adjusted OR: 1.206; 95% *CI*: 1.095 to 1.328, $p$ = 0.0002) (Markowicz, Wolff, Djedaini et al., 2000).

### 2.6.3 **Educational program**

Continuous nursing educational program is crucial and an effective tool in prevention of VAP (Cason et al., 2007; Danchaivijitr et al., 2005; Tablan et al., 2004). Study on nurse's knowledge related to VAP prevention is limited. Research elsewhere had found that experience does not correlate with quality of care. Meta-analysis of 32 out of the 62 (52%) published report showed declining tendency in performance of physicians with increasing years in practice for all outcomes assessed. Physicians who have been in practice longer maybe at risk for providing lower-quality care (Choudhry, Fletcher & Soumerai, 2005). Therefore, experienced healthcare workers may need quality improvement interventions in terms of update in knowledge to ensure quality care are delivered to patients in ICU. However, dissimilarity reported by Blot et al.

(2007) in a survey conducted during the annual congress of the Flemish Society for Critical Care Nurses. The study showed that the average knowledge level was higher among more experienced nurses (> 1 year experience) and those holding a special degree in emergency and intensive care (Blot, Labeau, Vandijck et al., 2007).

Decision is based on individual optimal knowledge, skills, opinions, attitudes, values, routines, or personalities (Kaier, Wilson, Hulscher et al., 2011). Therefore all the healthcare workers are educated. However, healthcare workers with deviant attitudes and values could hamper change, patient care and outcome.

Awareness (Aitken, Williams, Harvey et al., 2009), and education are essential in any prevention program crucial for processes of change (Aitken et al*.,* 2011). All critical care units should have continuous educational program in infection prevention and control for all healthcare workers delivering care for patients using mechanical ventilation (Tablan et al., 2004). Education is the key in preventing VAP (Smith Medical North America, 2009). Most researches recommended educational intervention delivered to nurses and respiratory care practitioners to reduce VAP rates in the ICU setting (Babcock, Zack, Garrison et al*.,* 2004; Tablan et al., 2004). Healthcare workers in ICU especially nurses are always with their patients, providing care and fulfilling their needs. Therefore it is crucial for them to be knowledgeable in the prevention of VAP. The 2003 CDC guidelines recommended staff education on local

epidemiology and infection control practices related to the prevention of VAP (SARI working group, 2011; Cason et al., 2007; Tablan et al., 2004). At least one multicenter study proved that educational program reduces VAP rate by 50%, thus effectively reduces costs and patient morbidity (Danchaivijitr et al., 2005). A study by Needleeman et al. (2004) reported that increase numbers of hours spent by nurses delivering care are statistically significant associated with a shorter length of stay in ICU, $p < 0.001$ (Needleman, Buerhaus, Mattke et al., 2004). This issue had been confirmed by Rello et al. (2010) the time allocated by nurses delivering care is significantly associated with better health for hospitalized patients (Rello, Lode, Cornaglia et al., 2010). Education and training (Rello et al., 2010; Bonten et al., 2004), motivation (Blot, Vandijck & Labeau, 2008) and rewarding staff (Huang & Wu, 2008) have also been shown to be an essential part of VAP prevention strategies. Many HCAI prevention guidelines exist (Abbott, Dremsa, Stewart et al., 2006; Tablan et al., 2004). However, the concern and challenge remains to ensure clinician to accept and practice the recommendations (Jarvis, 2007).

All ventilated patients must be on written order or standard protocol, for instance, all ventilated patients should be placed on semirecumbent position with additional order specifying angle of head-of-bed to be more than 30 to 45$^{o}$, likewise, intensivists, head-nurse and senior nurse must reinforce the importance of keeping and abiding to the guideline and constantly reminding nurses that patient should be in semirecumbent