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Ventilator-Associated Pneumonia: Nursing Implications

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Abstract: **Ventilator-associated pneumonia (VAP) is a major problem in the intensive care unit among mechanically ventilated patients and oral care can reduce the risk of developing VAP. Access to VAP increases health care costs due to increased duration of stay and most important; Ventilator-associated pneumonia has a negative impact on mortality and morbidity. Oral pharyngeal colonization was clearly an important mechanism for the development of VAP. Invasive mechanical ventilation (IMV) is a risk factor for the development of ventilator-associated pneumonia, which develops at least 48 hours after admission into patients who are ventilated through a tracheostomy or endotracheal intubation. Ventilator-associated pneumonia is the most common intensive care unit infection among patients receiving invasive mechanical ventilation. It contributes to increased hospital mortality, mechanical ventilation time, intensive care unit and length of hospital stay. Therefore, it exacerbates the patient's critical condition and increases the total cost of the hospital. Preventive measures have become imperative, to ensure control and reduce the incidence of VAP. Preventive measures focus on adaptive risk factors, mediated by strategies based on non-pharmacological and pharmacological evidence-based strategies recommended by guidelines. These measures aim to reduce the risks associated with endotracheal intubation and prevent the micro aspiration from pathogens to the lower airways.**

Keywords: **Ventilator-associated Pneumonia, Invasive mechanical ventilation, Nosocomial Pneumonia, Preventive measures, Nursing Implications.**

1. INTRODUCTION

Ventilator-associated pneumonia (VAP) is among the most widespread healthcare-associated infections in intensive care units (ICUs) and accounted for 50% of all healthcare-associated infections [1]. In many cases, the patient's underlying critical condition necessitates invasive procedures and diagnostics, which may contribute unavoidably to the patient's risk of colonization by the exogenous microbes [2, 3]. Further, VAP has been connected to the longer length of stay and higher mortality and morbidity rates. Indeed, nurses and health care providers (HCPs) play a crucial role in infection control in ICUs. However, not all health care providers are compliant with the recommended handwashing guidelines [4].

Invasive mechanical ventilation (IMV) represents a risk factor for the development of ventilator-associated pneumonia (VAP). Ventilator-associated pneumonia is a pulmonary infection that develops in patients on mechanical ventilation for more than 48h after admission in patients ventilated through a tracheostomy or endotracheal intubation and is caused by pathogens predominantly present in hospital settings [5-7].

Ventilator-associated pneumonia is an iatrogenic condition and increases dramatically with the time on mechanical ventilation, worsens the condition of the critical patient increases dramatically with the time on mechanical ventilation, delays intensive care unit (ICU) discharge, and leads to a substantial burden on patients' outcomes and healthcare systems [5,8]. Studies reported attributable mortality of approximately 10% with surgical patients and with mid-range severity of illness at the highest associated risk [9].

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The most efficient way to prevent VAP onset is reducing the exposure to risk factors for VAP. Therefore, intubation should be avoided whenever possible, and strategies such as non-invasive positive-pressure ventilation, sedation, and weaning protocols should be used to replace or shorten mechanical ventilation [10-12].

2. INCIDENCE

A study by [13] concerned with the analysis of VAP done in Egyptian University Hospitals in the last 10 years to describe the magnitude of the problem of VAP in Egypt, and to explore its predictors and its most common causative organisms. Depending on the data of this study, incidence in these university ICUs ranges from 16% to 75%. [14] In comparison with the incidence of VAP World Wide, 10–28% and in the United States 9–27%. Also study [13] reported that the incidence of VAP in these university Egypt ICUs is about 2.5 times more. The highest incidence, 75% was noted in Ain Shams University and the lowest incidence, 16% was at Alexandria University, while the incidence in Mansoura University was 22.6%. The incidence of VAP ranged from 16% to 75%, with the lowest ratio in Alexandria and the highest one in Ain Shams University.

Ventilator-associated pneumonia is a dynamic disease caused by a wide spectrum of pathogens and associated with morbidity and mortality. It accounts for up to 60% of all Healthcare-Associated Infections, 10–28% of critical care patients and increases the length of ICU stay by 28% [15].

Latest epidemiology studies report incidence rates of 13 cases per 1000 ventilator days [16]. Interestingly, American reports highlight a significant, and questionable, decline in VAP rates. This could be related to the better implementation of preventive strategies or simply too significant heterogeneity over time in VAP definitions, discrepancies among benchmarked hospitals and patient groups [17].

3. PATHOPHYSIOLOGY OF VENTILATOR-ASSOCIATED PNEUMONIA

Shortly after hospitalization, the upper airway becomes a colony with a variety of possible virulent bacteria, some of which can be multidrug-resistant, such as methycylline resistant bacteria (MRSA), and Pseudomonas aeruginosa. Endotracheal intubation impedes with mucosal protective measures in the respiratory tract and makes the cough reflex less effective. This enables the aspiration of pharyngeal secretions around and inside the endotracheal tube leading to the colonization of lower airways and VAP [18].

Ventilator-associated pneumonia developed over the translocation of endogenous (Fig. 1) or exogenous (Fig. 2) bacteria into the lower respiratory tract and this type of translocation may happen through hematogenous seeding, inhalation of bacteria from gastric colonization, contaminated respiratory equipment, or contiguous spread, VAP frequently resulted from oro-pharyngeal pathogen aspiration (Fig. 3) [19].

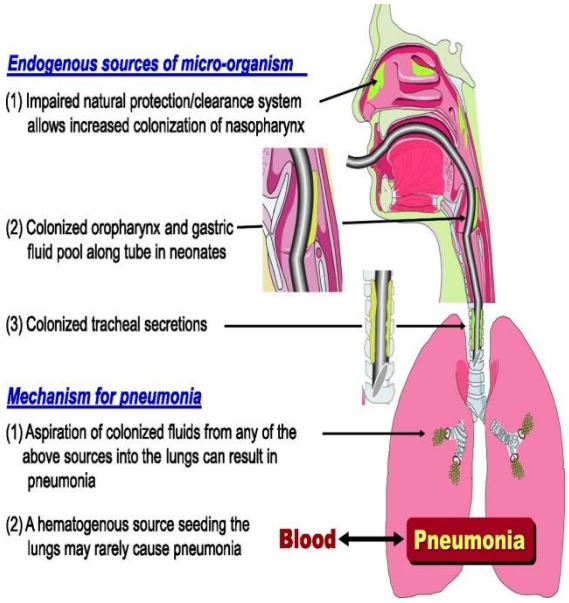

Figure (1) Endogenous Sources of Micro-organism

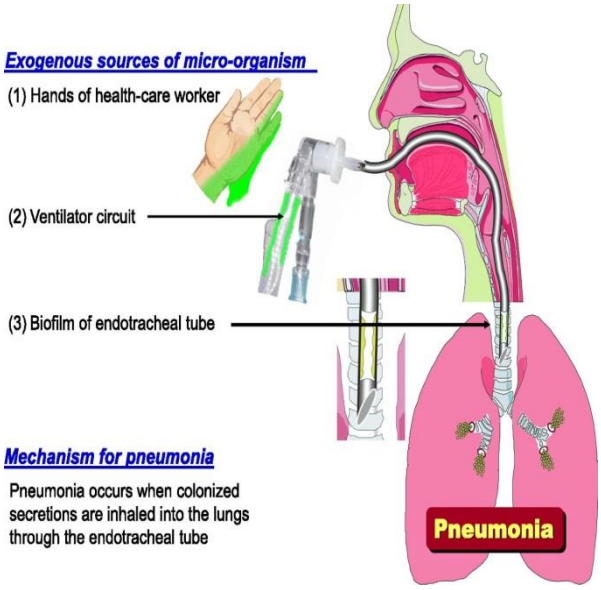

Figure (2) Exogenous Sources of Micro-organism

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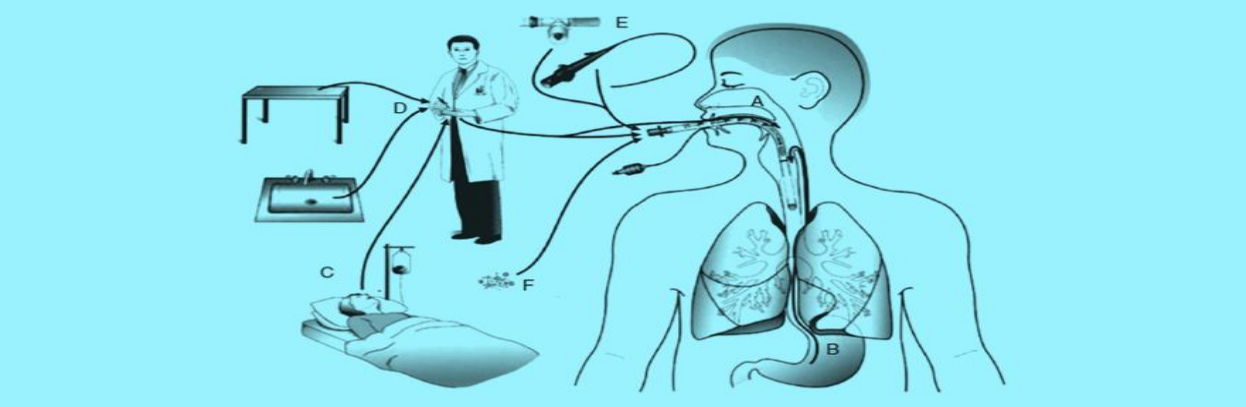

Figure (3) Routes of colonization/infection in mechanically ventilated patients. A- oral and pharyngeal colonization; B- gastric colonization; C- infected patients; D- handling of respiratory equipment; E- use of respiratory devices; and F- aerosols from contaminated air.

The ventilator-associated pneumonia onset consists of two (2) types: the early and late onset. Ventilator-associated pneumonia in the early- onset happens after intubation from 48 to 96 hours and related to antibiotic-susceptible organisms. Ventilator-associated pneumonia in the late-onset happens after intubation more than 96 hours and related to antibiotic-resistant organisms. There are two main processes occur in VAP that includes respiratory and aerodigestive tracts colonization and aspiration of the lower and upper respiratory tract secretions [20].

Many factors possibly contribute to the high VAP rates in ICU patients. First, there are groups of patients in ICUs that are highly vulnerable and they are predisposed to lung conditions, which compromise the defense mechanisms in the patient's airways. Second, aspiration is considered the most common means of acquiring pneumonia that is encouraged by supine positioning, upper airway, and nasogastric tube placement. Third, aerobic Gram-negative bacilli are the leading organisms in healthcare-associated pneumonia. These bacteria most probably reach the lower airway through secretions of the upper airway or from aspiration of gastric contents. Otherwise, the oropharyngeal colonization in healthy, non-hospitalized individuals with Gram-negative bacilli is uncommon [21].

4. DIAGNOSIS OF VENTILATOR-ASSOCIATED PNEUMONIA

The diagnosis of VAP is commonly based on three (3) components: new or worsening infiltrates seen on the chest X-ray, systemic signs of infection, and bacteriological evidence of pulmonary parenchymal infection. Leukocytosis, fever, and tachycardia as systemic signs of infection are nonspecific findings and may be caused by any disorder that releases cytokines. Even though, chest x-ray (usually portable) remains an important element in the evaluation of suspected pneumonia and it is most useful when it is normal and rules out pneumonia [21].

Since the clinical findings of VAP are nonspecific and the differential diagnosis can be broad, the VAP diagnosis is difficult. Findings such as the combination of radiographic infiltrate and 2 of 3 clinical features (fever >38_C, increased white blood cell (leukocytosis)/decrease white blood cell (leukopenia), purulent secretions) are used as a reference at autopsy level resulted in 75% specificity for pneumonia and 69% sensitivity. Ideally, diagnostic lower respiratory tract sampling for quantitative culture and microscopic evaluation where recommended when VAP is suspected [22].

Bronchoscopic broncho-alveolar lavage (BAL) is preferred to obtain a sample from left lower lobe in patients with infiltrates and possible VAP; because in the right lower lobe bronchus, mini-BAL sampling catheters most commonly advance [23]. Samples obtained from the lower respiratory tract for microbiology and culture is recommended by the guidelines of Infectious Diseases Society of America (IDSA) and the American Thoracic Society (ATS). Analysis of these samples can be qualitative or quantitative [2].

A study by [24] stated that the mainly that there are four diagnostic protocols which if followed identifies classical signs and symptoms of VAP by new or progressive diffuse infiltrate in Chest X-ray which is not related to any other cause; onset of purulent sputum; body temperature more than 38.5°C (101°F); increased white blood cell (WBC) (Leukocytosis), sputum or blood positive cultures.

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5. VENTILATOR-ASSOCIATED PNEUMONIA RISK FACTORS

Several risk factors were identified and showed increased VAP rates. These factors are divided into modifiable and non-modifiable. Modifiable risk factors include gastric over-distention, lying position, frequent patient transfer, colonization of ventilator circuits, and low pressure of the tracheal tube cuff. Non-modifiable factors include chronic obstructive pulmonary disease (COPD), male gender over 60 years, coma, acute respiratory distress syndrome (ARDS), re-intubation, multi-organ failure, tracheostomy, neurosurgery and cranial trauma [25, 26].

According to [24] stated that the endotracheal tube (airway intubation) was identified as one of the largest risk factors for VAP. It is unavoidable because, without the endotracheal tube, mechanical ventilator support (or another artificial airway) cannot be performed. Bypassing many "natural protection" mechanisms, the endotracheal tube will provide a direct way into the lungs.

Studies by [27, 28] identified two risk factors for VAP namely ventilation-related factors (equipment of the airway with an endotracheal tube and subsequent micro aspirations) and, less frequently, patient-related factors (pre-existing pulmonary disease, disease history and dependent illness, male gender ,old age, previously central nervous system disorder, immunocompromised, acute underlying diseases, emergent surgery, neurosurgery, thoracic surgery, cardiac surgery, burns , re-intervention, acute severity factors, organ system failure index of at least 3, acute renal failure, acute respiratory distress syndrome, intra-aortic support, and ulcer disease).

6. PREVENTION OF VENTILATOR-ASSOCIATED PNEUMONIA

Prevention of VAP is much more cost-effective than treatment, and several guidelines have recommended measures to decrease VAP incidence. The most important measures stand for continuous aspiration of subglottic secretions, oral hygiene with chlorhexidine, continuous medical education, semi recumbent-position, and selective digestive decontamination [29].

The principles of basic infection control like hand washing, optimal resource use, and adequate ICU staff education are necessary. Infection prevention strategies include (1) reducing aspiration into the lower airway by contaminated secretions and (2) reducing bacterial colonization of the aerodigestive tract. Bacterial colonization can be decreased by using chlorhexidine in the posterior pharynx, decreasing the duration of mechanical ventilation over-weaning protocols and silver-coated endotracheal tubes [22].

In addition, VAP prevention for mechanically ventilated patients is a major challenge and a significant concern for critical care nurses. Identifying early symptoms of VAP, reducing risk factors, and implementing relevant preventive measures are an important role for critical care nurses. These measures have evidence for decreasing the incidence of VAP and improving patient outcome [29].

7. TREATMENT OF VENTILATOR-ASSOCIATED PNEUMONIA

The principles to be applied when selecting the suitable treatment for VAP include knowledge of potentially living organisms, local resistance patterns within the intensive care unit, a logical antibiotic system, and the rationale for removing antibiotic de-escalation or cessation. Early effective treatment of VAP is associated with low mortality. Delayed treatment was appropriate for 24 hours or more with 69.7% mortality, compared with 28.4% in patients treated without delay ($P < 0.001$). Thus, once VAP is considered, cultures must be obtained quickly and treatment initiated immediately [30].

Assessment of current antimicrobial strategies: Successful treatment of patients with VAP remains a difficult and complex task. Despite extensive clinical experience with the disease, no consensus was reached on key issues such as optimal antimicrobial system or duration. Antimicrobial strategies to treat bacterial VAP were difficult for several reasons. The final diagnostic criteria for VAP should still be developed in critically ill patients. However, it is hard to differentiate between bacterial culture of the tracheal tree and real hospital pneumonia [31].

A study by [32] classified VAP prevention methods as ''functional'', ''mechanical'' or ''pharmacological'' (Table 1)

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Table 1 Classification of VAP prevention methods.

Functional
1. Semi-lying down position
2. Strict hand cleanliness with alcohol-based gels or solutions before airway management
3. Teaching and training in aspiration of bronchial secretions
4. Daily anesthesia vacation and assessment of weaning and extubation
5. Availability of weaning protocols
6. Early tracheostomy
7. Non-invasive mechanical ventilation
8. Microbiological monitoring of cross-contamination and infection
9. Installation of normal saline prior to endotracheal suction
10. Ventilator tubing change
11. Route of endotracheal intubation. Orotracheal vs. nasotracheal
12. Type of airway moisturizing. Preference of heat moisture exchanger or heated humidifier
13. Physiotherapy
14. Positive end-expiratory airway pressure (PEEP) of 5---8 cmH2O vs. Zero end-expiratory pressure (ZEEP) in patients without lung injury
15. Enteral feeding: route of administration and gastric residual volumes. Use of prokinetics
Mechanical
1. Endotracheal tube cuff pressure monitoring
2. Subglottic secretion drainage
3. Polyurethane-cuffed endotracheal tubes
4. Polyurethane-cuffed endotracheal tubes with subglottic secretion drainage
5. Silver-coated endotracheal tubes
6. High-volume, low-pressure endotracheal tube cuff
7. Small caliber feeding tubes
8. Aspiration of tracheobronchial secretions with closed vs. open systems
9. Endotracheal tube biofilm removal device (Mucus Shaver®)
10. Kinetic bed therapy
11. Airway filters
12. Water-soluble gel lubrication of the endotracheal tube
13. Tooth brushing
Pharmacological
1. Selective decontamination of the digestive tract
2. Selective oropharyngeal decontamination
3. A short course of intravenous antibiotic
4. Oral hygiene with chlorhexidine
5. Nebulized antibiotics
6. Antibiotic cycling
7. Probiotics

8. NURSING IMPLICATIONS TO PREVENT VENTILATOR-ASSOCIATED PNEUMONIA

Healthcare-associated infections (HAI), such as ventilator-associated pneumonia (VAP), is the most common and most preventable complication of hospital stay. Usually, VAP rates have been measured as an indicator of quality of care. Despite latest initiatives to measure mechanical ventilation complications and low incidence over the past few years, VAP remains a problem for seriously ill patients, with an expected mortality rate of up to 10%. [33].

1. DECREASE VENTILATOR EXPOSURE

The most significant indication to diminish VAP risk is to reduce patient contact to mechanical ventilation, which can be accomplish in two ways. Initial, by reassuring the use of non-invasive ventilation techniques, such as positive double-level airway pressure or continuous positive air pressure. Second, when mechanical ventilation cannot be avoided, reduce

its duration. Ventilator weaning protocols or evidence-based care packages can be in effect of shortening the duration of mechanical ventilation. Breathing protocols led by the nurse and respiratory therapist, which include the daily interruption of anesthesia and coordination with the experience of spontaneous breathing were effective in removing patients from mechanical ventilation rapidly and properly [34].

2. PROVIDE BETTER ORAL HYGIENE CARE

Oral health worsens rapidly in patients undergoing mechanical ventilation. Some patients suffer from oral mucosa injuries during the process of intubation, and after intubation, patients are liable to dry mouth. These factors, in addition to a compromised immune system, can cause an increase in bacterial colonization of the oral mucosa, where the endotracheal tube acts as a direct route to the lungs [35].

Proper oral care can reduce the growth of bacteria and reduce the risk of infection. In the meta-analysis of more than 18 randomized controlled trials (RCTs), routine oral care with chlorhexidine reduced the incidence of VAP. Currently, there are no guidelines for the frequency of oral hygiene. A recent systematic review of 38 randomized controlled trials has shown that oral care is done anywhere from 1 to 4 times a day. Providing oral care, a routine part of the patient's ICU assessment, is one way to improve his frequency. Consider the development of a specific unit protocol with a clear articulation of roles and responsibilities [36].

3. CARE FOR SUBGLOTTIC SUCTIONING

Decolonization and the incidence of VAP have been shown by standardization of endotracheal suction protocols. Subglottic secretion suctioning can be performed by the nurse and respiratory doctor and can assist in prevention. The meta-analysis of 20 randomized controlled trials found that subglottic suctioning reduced the risk of VAP by 45% compared to patients who did not receive the suctioning. Coordination of subglottic suctioning when oral care may be a good mechanism for cluster care and to ensure routine delivery of these practices [37, 38].

4. MAINTAIN OPTIMAL POSITIONING

Maintaining the correct position of the high bed head between 30-45 °, (near-lying position) is recommended to reduce gastric reflux, aspiration, and subsequent risks of VAP. Encourage early movement to help patients who are mechanically ventilated in prevention of VAP, but lead to days without ventilator. Indication supports the possibility of early movement for critically ill patients, even after a short time [39].

5. ENSURE PROPER TRAINING OF STAFF

Adequate nurses in the intensive care unit, especially for mechanically debilitated patients, can help reduce VAP risk. It provides nurses with the time, chances and resources to implement care practices that reduce risk and allow them to spend more time with their patients, which may lead to early identification of VAP and prompt treatment. Healthy work environments and inter-professional have also been associated with reduced VAP risk. Education and promotion are required for all behavioral changes. Therefore, education is the first step in the best practice program for VAP, followed by aspiration and reduction of pharyngeal oral colonization. For a successful program, educating employees about VAP is critical. [40]

9. CONCLUSION

- Morbid complications of ventilated patients are common but many are preventable.
- Focus on preventive care practices; elevate the head of the bed, regular oral care with antiseptic and daily sedation interruption and assessment of readiness to extubate.
- Regular monitor adherence of preventive care practices and provide feedback to frontline staff
- Implementation of prevention strategies has the potential to improve patient outcomes and reduce health care costs.
- Importance of continuing education about VAP prevention strategies, which would promote positive patient outcomes.

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