Ventilator-Associated Pneumonia (VAP): Overview And Preventive Strategies

Dr. Gautam Rawal¹, Dr. Raj Kumar², Dr. Sankalp Yadav³, Ms. Sujana R⁴

¹Associate Consultant-Respiratory Intensive Care, Max Super Specialty Hospital, Saket, New Delhi, India.
²Senior Consultant and Incharge-Respiratory Intensive Care, Max Super Specialty Hospital, Saket, New Delhi, India.
³General Duty Medical Officer-II, Department of Medicine & TB, Chest Clinic Moti Nagar, North Delhi Municipal Corporation, New Delhi, India.
⁴Infection Control Unit, Max Super Specialty Hospital, Saket, New Delhi, India.

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ABSTRACT

Ventilator-associated pneumonia (VAP) is among the most commonly encountered nosocomial infection associated with significant morbidity and mortality, and also adds to hospital length of stay and increased cost. Studies have shown the attributable risk of mortality associated with VAP at about 9-13%. Over the years numerous studies have been done focusing on VAP prevention and multiple strategies have been postulated. The interventions that have been proved to be beneficial in preventing VAP include: (i) Non-invasive positive pressure ventilation for the able patients, (ii) Sedation break and weaning protocols, (iii) head of bed elevation above 30 degrees and oral care, and (iv) removal of the subglottic secretions.
INTRODUCTION:
Definition: Ventilator-associated pneumonia (VAP) is defined as the pneumonia occurring in the patients on mechanical ventilation (endotracheal tube or tracheostomy) for at least 48 hours and is characterized by a new or progressive infiltrate on chest X-ray, signs of systemic infection (temperature, blood cell count), any change in the characteristic of sputum/phlegm, and detecting the causative agent/organism [1, 2]. The authors given a brief overview and enumerate the strategies for the prevention of VAP.

VAP is commonly encountered hospital-acquired infection (HAI) or nosocomial infection seen in the intensive care unit and requires prolonged mechanical ventilation, increased antibiotic usage leading to possible high rates of multidrug-resistant infections, associated with poor clinical outcomes and increased hospital length of stay (high healthcare cost). VAP rates have been traditionally used as quality indicator for healthcare setting. Multiple research trials have shown that the critical patients tend to have a higher incidence of VAP due to their impaired physiology to prevent infection, decreased or altered immune response and the presence of multi-organ dysfunction. The recent studies show the attributable risk of mortality associated with VAP at about 9-13% [3, 4].

Risk factors for VAP:
All patients who are on mechanical ventilation are at the risk of developing VAP. Numerous studies have described the rate of contracting VAP as 3 per cent per day during the first week of mechanical ventilation, 2 per cent per day during the second week and 1 per cent per day thereafter [5, 6]. Depending on the criteria used for the diagnosis of VAP the overall incidence ranges from 5 to as high as 67 per cent [5]. The various risk factors associated with VAP have been tabulated in Table 1[5, 6]:

<table>
<thead>
<tr>
<th>Table 1: Risk factors associated with VAP</th>
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<tbody>
<tr>
<td><strong>Patient associated</strong></td>
</tr>
<tr>
<td>Non-modifiable risk factors</td>
</tr>
<tr>
<td>• Age(&gt;60years)</td>
</tr>
<tr>
<td>• Sex(Males)</td>
</tr>
<tr>
<td>• Medical conditions (Pre-existing pulmonary diseases, HIV infection)</td>
</tr>
<tr>
<td>• Acute Respiratory distress syndrome, Chronic obstructive pulmonary disease, Multi–organ failure</td>
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<tr>
<td>• Head trauma, neurological surgery, coma</td>
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<tr>
<td>Modifiable risk factor</td>
</tr>
<tr>
<td>• Intubations (number and frequency)</td>
</tr>
<tr>
<td>• Body position of patient (supine position)</td>
</tr>
<tr>
<td>• Use of medications/antibiotic</td>
</tr>
<tr>
<td>• Gastric over-distension</td>
</tr>
<tr>
<td><strong>Device associated</strong></td>
</tr>
<tr>
<td>• Endotracheal tubing and Ventilator circuit colonization with microbes</td>
</tr>
<tr>
<td>• Low pressure in the ET cuff</td>
</tr>
<tr>
<td>• Orogastric or Nasogastric tubes</td>
</tr>
<tr>
<td><strong>Healthcare Personnel related</strong></td>
</tr>
<tr>
<td>• Inappropriate hand hygiene practice (hand wash/cleansing, glove changing)</td>
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<tr>
<td>• Lack of use of personal protective equipment’s in cases with antibiotic resistant pathogens.</td>
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</tbody>
</table>
Pathogenesis of VAP:
There is a complex interplay of multiple factors leading to development of VAP. These include: the presence of an endotracheal tube (ETT), various risk factors (as stated above), virulence of the invading bacteria and patient’s immune status. The determining factor for developing VAP is the presence of an ETT. The ETT nullifies the natural defense mechanism of the body (cough reflex of glottis and larynx) and favors micro aspiration around the cuff of the tube. The oropharynx and the upper respiratory tract of mechanically ventilated critically ill patients are colonized by pathogenic microbes (usually gram negative bacteria) in almost 75% of the cases, which was demonstrated as early as in 1969 in a study [7]. These microbes can migrate to the lower respiratory tract through the following mechanisms: (1) aspiration/micro aspiration occurring during the time of intubation; (2) formation of biofilm laden with bacteria (commonly Gram-negative bacteria and fungal species) within the endotracheal tube; (3) pooling and subsequent trickling of secretions around the ETT cuff; and (4) supine position of patients, along with sedation, leads to impairment of mucociliary clearance of the secretions resulting in gravity dependent flow of the mucus into the airways.

Another mechanism which play important role in development of VAP is the retrograde flow of pathogenic organisms colonizing the surrounding anatomic structures: upper gastrointestinal tract (esophagus, stomach), sinuses, and nasopharynx, along with the positive pressure of ventilation causing the forward thrust. This was proven in 2007 by the study which demonstrated the presence of similar bacteria over tongue and lower respiratory tract in patients of VAP [8].

VAP Prevention:
After knowing the risk factors and the pathogenesis of VAP, authors now discuss the various strategies for its prevention:

A) Decreasing the time at risk:
As described above, the risk factor of VAP include the presence of an ETT and the duration of mechanical ventilation. Therefore limiting the time of mechanical ventilation or avoiding the mechanical ventilation at first place, plays an important role. This can be achieved by:-
1) Non-invasive positive pressure ventilation (NIPPV): Multiple studies have proven the fact that the use of NIPPV instead of ETT, in the possible cases significantly decreases the risk of VAP and thus lower the mortality/morbidity associated with VAP [9, 10].
2) Daily sedation holidays and weaning trials: Having a protocolized approach to liberate the patient from mechanical ventilation by giving sedation breaks and following a weaning protocol including early mobility often results in less number of ventilator days [11, 12].
3) Avoiding re-intubation: It has been observed that re-intubation or weaning failure after extubation is associated with higher risk of aspiration leading to higher rates of VAP. Therefore extubation should be carefully planned in a protocolized manner and also care should be taken to prevent unplanned extubation or self extubation by the patient [13]. Early tracheostomy has not shown to decrease the rates of VAP [14].

B) Decreasing the microaspiration and endotracheal tube colonization
1) Endotracheal tubes with subglottic suction: Studies showed that the use of ETT having subglottic suction port decreased rate of VAP incidence [15, 16]. The port is used intermittently or for continuous suction helps to remove the pooled-up secretions above the ETT cuff, thus preventing aspiration.
2) Patient position and Head of bed elevation: Patients positioned in semi-recumbent 30-45° have been shown to have lesser incidence of VAP as compared to patients in supine position [17, 18]. This is due to the fact that semi-recumbent position reduces the aspiration of the gastric content.
3) Antimicrobial-coated endotracheal tubes:
Antimicrobial coated ETTs (silver-coated ETT) have
been shown to decrease intra-luminal bacterial colonization and biofilm formation. It is based on the hypothesis that the microorganisms from the oropharynx or gastric reflux upon reaching the ETT inner-lumen surface produce a biofilm which protect the organism against the patient’s natural defense mechanisms and helps in bacterial proliferation [19-22]. When these biofilm gets dislodged spontaneously or due to suctioning/bronchoscopy, they pose a significant risk of causing VAP. Also, the silver coated ETT have bactericidal properties, thus reducing the bacterial burden. These silver-coated ETT, though available, have to prove their efficacy in long run. ETT with other antimicrobial coating material like chlorhexidine with or without sulphadiazine are still undergoing clinical trials.

C) Infection control in the ICU
The purpose for infection control is preventing the cross transmission of pathogens. The preventive strategies must be focused on education of the healthcare personnel, use of proper and recommended hand hygiene methods, use of personal protective equipments as indicated, and microbiological surveillance [23-25]. All the healthcare providers should be motivated and educated to follow the preventive guidelines to decrease the incidence of hospital acquired infections.

D) Prevention of bacterial colonization
Prevention of bacterial colonization of the oropharynx, upper airway and gastrointestinal tract has shown to decrease the incidence of VAP. It includes oral decontamination, selective decontamination of the digestive tract (SDD), and the use of probiotics. Oral decontamination with chlorhexidine has been used extensively in numerous research studies and has been shown to reduce the rate of VAP [26-28]. SDD refers to the use of antibiotics for eradication of potentially pathogenic microorganisms present in the oral cavity, stomach and intestine. Although studies have shown its benefit but SDD is not routinely recommended due the risk emergence of antibiotic-resistant microbes [29-31].

Probiotics: A study published in 2010 concluded that critical patients who at high risk for VAP and received Lactobacillus rhamnosus had significantly lesser microbiologically confirmed cases of VAP as compared to patients who did not receive the probiotics [32]. However, multi-center clinical trials at a larger scale are required to evaluate the generalizability of this finding and its routine recommendation.

Mechanical Ventilation Management:
Ventilator circuit change: The circuit must be changed only when visibly soiled or there is circuit malfunction, and not on a routine basis [33]. ETT cuff pressure should be regularly monitored to prevent micro-aspiration (pressure to be kept above 20 cm of H2O) [34]. The use of Heat and Moisture Exchangers (HME) filters for humidification has not shown any significant result in reducing the rate of VAP [35].

VAP Bundle:
VAP prevention studies have grouped together major components of VAP prevention for the healthcare providers. The bundle for VAP includes four components: (a) elevation of the head end of the bed to 30-45º, (b) daily interruption of sedation or the sedation holiday, (c) daily assessment of the patient for readiness to extubate and (d) prophylaxis for deep venous thrombosis and peptic ulcer disease. The VAP bundle approach for prevention has been found to be highly effective in reducing its incidence and the associated mortality and ICU length of stay [35].

CONCLUSION
In a developing country like India, VAP is a serious and challenging nosocomial infection, carrying significant morbidity/mortality, increased antibiotic utilization, prolonged hospital stay and high healthcare cost. Preventive strategies for decreasing the incidence of VAP need understanding of the various risk factors, its pathophysiology and a protocolized approach.

The interventions that have been proved to be beneficial in preventing VAP include: (i) the use of NIPPV for the able patients, (ii) daily sedation breaks and weaning protocols, (iii) head of bed elevation above 30 degrees and oral care, and (iv) removal of subglottic secretions.

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