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REVIEW ARTICLE

PREVENTIVE STRATEGIES FOR VENTILATOR ASSOCIATED PNEUMONIA: CHALLENGES AND CONTROVERSIES

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ABSTRACT: Ventilator associated pneumonia continues to be a cause of significant morbidity and mortality in critically ill patients. VAP is the second most common nosocomial infection in intensive care units, affecting 27% of all critically ill patients. In the last ten years, American, Canadian, European and Irish scientific societies have documented their evidence based guidelines on the prevention of VAP. The intent of this article is to provide concise and practical knowledge for the bedside clinicians in ICU to aid in VAP prevention efforts. It also focuses on the controversies with regard to diagnostic tools and approaches, treatment plans and prevention strategies.
KEYWORDS: Ventilator associated pneumonia; anaesthesia; guidelines; strategies.

INTRODUCTION: Ventilator associated pneumonia is defined as pneumonia occurring more than 48 hours after patient has been intubated and received mechanical ventilation. Eighty-six percent of nosocomial pneumonias associated with mechanical ventilation are termed as ventilator-associated pneumonia (VAP). Mortality caused due to VAP is significantly high (13% to 55%). The organisms recovered have an impact on outcome, with higher mortality rates seen in VAP caused by Pseudomonasaeruginosa, Acinetobacter and Stenotrophomonasmaltophilia.[1] Beyond mortality, the economics of VAP include increased ICU length of stay (LOS) (from 4 to 13 days), and incremental costs associated with VAP has been estimated at between $5, 000 and $20, 000 per diagnosis.[2-4]

However, VAP is preventable and many practices have been demonstrated to reduce the incidence of VAP and its associated burden ofillness.[5, 6] To establish diagnosis of ventilator-associated pneumonia is really a challenge in critically ill patients because of the presence of underlying cardiopulmonary disorders like aspulmonarycontusion, acute respiratory distress syndrome, atelectasis and the nonspecific radiographic and clinical signs associated with this infection. Diagnosis of VAP requires special emphasis on clinical signs combined with radiographic examination, and microbiologic analysis.

A new streamlined surveillance definition for ventilator-associated pneumonia includes:
Any one of the following

- Opacity, infiltrate, or consolidation that appears, evolves, or persists over > 72 hours.
- Cavitation.

Any one of the following:

- Temperature >100.4°F within past 24 hrs.
- Leucopenia<4, 000 or leucocytosis >12, 000 white blood cells/mm3 within past 24 hours.

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Both of the following:

- Two days of stable or decreasing daily minimum FIO2 followed by increase in daily minimum FIO2 >15 points sustained for >2 calendar days OR 2 days of stable or decreasing daily minimum positive end-expiratory pressure followed by increase in daily minimum positive end-expiratory pressure by >2.5 cm H2O sustained for >2 calendar days and.
- Gram-negative stain of respiratory secretions with moderate (2+) or more neutrophils per low-power field within 72 hrs.

It may be early or late onset depending upon the time of onset. Early onset is defined as pneumonia occurring less than 96 hours of intubation or ICU admission. It is community acquired, antibiotic sensitive having good prognosis and outcome. The causative micro-organisms generally are streptococcus pneumonia, haemophilus influenzae and staphylococcus aureus. Late onset type occurs more than 96 hours of intubation or ICU admission. It is hospital acquired, antibiotic resistant having poor prognosis. The pathogens responsible are pseudomonas aeruginosa, methicillin resistant staphylococcus aureus (MRSA), acitenobacter and enterobacter.

Various strategies have been investigated in order to reduce the incidence of VAP. Almost a decade ago, an education based program at Barnes-Jewish Hospital directed towards respiratory care practitioners and ICU nurses was developed by a multidisciplinary task force to highlight correct practices for the prevention of VAP.[7] Lansford et al[8] also developed a simple bundle for the prevention of VAP in trauma patients, focusing on head of bed elevation, oral cleansing with chlorhexidine, a once-daily respiratory therapist-driven weaning attempt, and conversion of nasogastric to orogastric feeding tubes. Elements of this bundle also have been shown to be effective in other surgical/trauma units at Barnes-Jewish Hospital.[9] Boudama et al[10] recently publisheda multimodal intervention strategy for VAP prevention with a strong emphasison process control. This French intervention included a multidisciplinary taskforce, an educational session, and direct observations with performance feedback, technical improvements and scheduledreminders. Bouadma's eight evidence-based bundled interventions includes Hand hygiene, preferably alcohol-based hand-rubbing; Glove & gown use for endotracheal tube manipulation; Back-rest elevation of 30 to 45 degrees; racheal cuff pressure maintenance 20 cm H2O; Use of orogastric tubes; Avoidance of gastric over distension; Oral hygiene with chlorhexidine; Elimination of nonessential tracheal suction.

All these strategies are likely to be successful only if based upon a sound understanding of pathogenesis and epidemiology. The major route for acquiring VAP is oropharyngeal colonization by endogenous flora or by pathogens acquired exogenously from the intensive care unit environment, especially the hands or apparel of health-care workers, contaminated equipment, hospital water or air. The stomach represents a potential site of secondary colonization and reservoir of nosocomial gram-negative bacilli.

Strategies to decrease modifiable risk factors responsible for VAP:

General Prophylaxis:

a) Effective infection control measures: staff education, compliance with alcohol-based hand disinfection and isolation to reduce cross-infection with MDR pathogens.

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b) Surveillance of ICU infections, to identify and quantify endemic and new MDR pathogens, and preparation of timely data for infection control and to guide appropriate, antimicrobial therapy in patients with suspected HAP.[11-13]
c) Maintaining adequate staffing levels in the ICU can reduce length of stay, improve infection control practices, and reduce duration of mechanical ventilation.[14,15]

Intubation and Mechanical Ventilation:

a) Non-invasive ventilation should be used whenever possible.[16-18]
b) Consider use of non-invasive ventilation to shorten the duration of invasive ventilation.[19-21]
c) Avoid continuous use of paralytics as far as possible as paralytics may prolong the duration of ventilation and increase the incidence of VAP [22].
d) Ensure appropriate dosage of sedation or narcotics using sedation scale to avoid over-sedation[22, 23].
e) Interrupt or lighten sedation (sedation vacation) daily at an appropriate time to assess patient's readiness for extubation.[24, 25]
f) Wean patient off invasive ventilation as soon as possible.[21, 22]
g) Prevent unplanned, accidental and patient selfextubation.[19, 23]
h) Unnecessary re-intubation may increase the risk of VAP.[26, 27]
i) Orotracheal intubation and orogastric tubes are preferred over nasotracheal intubation and nasogastric tubes to prevent nosocomial sinusitis and to reduce the risk of VAP.[28, 29]
j) Endotracheal tube cuff pressure should be maintained at greater than 20 cm H2O to prevent leakage of bacterial pathogens around the cuff into the lower respiratory tract.[30,31]

Body Position and Enteral Feeding:

a) Patients should be kept in the semi recumbent position (30–45°) rather than supine to prevent aspiration, especially when receiving enteral feeding.[32-36]
b) Enteral nutrition is preferred over parenteral nutrition to reduce the risk of complications related to central intravenous catheters and to prevent reflux villous atrophy of the intestinal mucosa that may increase the risk of bacterial translocation.[37, 38]
c) Enteral feeding may be a risk for aspiration in an intubated patient because of loss of cough reflex in these patients.
d) Avoid gastric over distension by decreasing the volume of each feed. Also patients fed into the stomach had more episodes of gastro esophageal regurgitation and micro aspiration compared with patients fed beyond the pylorus.

Modulation of Colonization: oral Antiseptics and Antibiotics:

a. Routine prophylaxis of VAP with oral antibiotics (selective decontamination of the digestive tract or SDD), with or without systemic antibiotics, reduces the incidence of VAP but is not recommended in patients who may be colonized with MDR pathogens.[39, 40]
b. Prophylactic administration of systemic antibiotics for 24 hours at the time of emergent intubation has been demonstrated to prevent VAP in patients with closed head injury.[41]
c. Modulation of oropharyngeal colonization by the use of oral chlorhexidine has prevented VAP in selected patient populations such as those undergoing coronary bypass grafting.

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Care of the Respiratory Care Equipment: The policies and practices for disinfection, sterilization and maintenance of respiratory equipments should be aligned with evidence-based standards. Re-used respiratory accessories, including the breathing systems used for anesthesia, respirometer, resuscitation bag, nebulizer and test lung, should be properly cleansed and decontaminated after each use.[22]

a) Allocate individualized respiratory equipment for each patient as far as possible.[42]
b) Provide a new set of disposable or high level disinfected ventilator tubing for each patient.
c) Change ventilator tubing when it is visibly soiled. No scheduled changes are recommended.[18]
d) Use sterile water to fill the humidifier of ventilator. It is an acceptable option to set up a closed water-refilling system to minimize manipulation of the humidifier system.
e) Change suction collection canisters and tubings for all patients.
f) Handle and store disinfected respiratory equipment or sterile items properly to preserve its sterility.
g) Check the expiry date and inspect the package of sterile respiratory items before use.
h) Ensure the disinfected respiratory equipment (e.g. nebulizer) is not re-contaminated during rinsing process. Sterile water should be used.[11,19]
i) In-line medication nebulizers: Use single dose vial of sterile medication or solution for nebulization whenever available. If multi-dose medication vials are used, ensure its sterility is maintained by proper storage and handling.[11]

Prevent Condensate from Ventilator Circuit Drain towards the Patients:

a) Position the ventilator's humidifier below the bed level to prevent condensation from draining toward the patients.[24]
b) Drain the condensate from ventilator tubing to water traps periodically.[24,27]
c) Always drain ventilator tubing and remove oral secretion before repositioning patient.

Prevent Leakage of Subglottic Secretion into the Lower Airway:

a) Maintain the tracheal tube cuff pressure adequately to prevent the leakage of secretion into the lower airway.[21, 24]
b) Ensure oral and subglottic secretion is cleared before tracheal cuff deflation.[11]
c) Consider use of subglottic drainage endotracheal tube and tracheostomy tube for patients requiring mechanical ventilation > 72 hours. Subglottic secretion drainage system consists of an accessory aspiration conduit opening above the ETT cuff and a vacuum source. Secretions may be continuously or intermittently removed from the subglottic space.[20]

Oral Care:

a) Daily assessment of oral hygieneand brushing the teeth with antiseptic toothpaste every 12 hourly to prevent plaque formation.
b) Oral cleansing with chlorhexidine2- 4 hourly androutine suctioning of mouth to minimize risk of aspiration and use of a moisturizer to prevent mucositis helps in a big way in preventing oral flora disturbances.

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Airway Humidification: Humidifiedair is important for adequate ventilation and oxygenation. It can be provided using heat and moisture exchangers (HMEs) and heated humidifiers. HMEs are a better choice in view of cost effectiveness and easy to handle, though no change is documented in VAP rates with the use of either device.[43]

Endotracheal Suction System: There are two types of suction systems: open and closed. No significant difference in the incidence of VAP is seen with either of the two. But closed type is preferred because of the safety considerations for the healthcare worker exposure and cross contamination by the aerosolized secretions.

Hand Hygiene: WHO has designed Five Moments of Hand Hygiene on basis of the evidence concerning DAI prevention and control. It states hand washing before the patient contact, before an aseptic task, after body fluid exposure risk, after the patient contact and after contact with patients surroundings. This simple but important practice, if routinely followed can miraculously decrease all types of nosocomial infections.[44]

Stress Bleeding Prophylaxis, Transfusion, and Hyperglycemia:

a) There is a trend toward reduced VAP with sucralfate, but there is a slightly higher rate of clinically significant gastric bleeding, compared with H_2 antagonists. If needed, stress bleeding prophylaxis with either H_2 antagonists or sucralfate is acceptable.[45]
b) Transfusion of red blood cell and other allogeneic blood products should follow a restricted transfusion trigger policy; leukocyte-depleted red blood cell transfusions can help to reduce HAP.[46]
c) Intensive insulin therapy is recommended to maintain serum glucose levels between 80 and 110 mg/dl in ICU patients to reduce nosocomial blood stream infections, duration of mechanical ventilation, ICU stay, morbidity, and mortality.[26]

CONTROVERSIES: There are no specific guidelines and recommendations regarding timing of tracheostomy and use of bacterial filters. Early tracheostomy definitely decreases the duration of mechanical ventilation and ICU stay. It also prevents the complications of laryngeal injury and tracheal stenosis. A higher level of research is needed to actually comment on its early intervention.

Most debated yet unresolved is institution of prophylactic intravenous as well as aerosolized antibiotics in suspected patients in view of theoretical concerns about the emergence of resistant bacteria despite the apparent benefit in terms of lower VAP rates. The timing to start the antibiotics is nowhere specified but individualized by the physician. This needs more specific considerations and extensive research work on local factors.

The practice of saline instillation in the tracheal tube to loosen secretions has been condemned as it may have potential detrimental effects such as decreasing oxygenation levels and causing contamination. But study by Caruso and colleagues have shown that saline instillation before tracheal suction decreases VAP rates by removing thick, tenacious secretions[47]. Also by stimulating cough reflex, secretions are easily and maximally sucked out thereby decreasing biofilm formation.

Future Prospectives: Spheres of interest that need to be explored are the modifications in the ETT like tube with an ultrathin cuff membrane and antimicrobial coating, tube a low-volume/low-

pressure cuff, device for continuous monitoring of cuff inflation pressure and removal of biofilm. Patient positioning in the lateral and prone position, kinetic therapy and administration of probiotics are measures worthy of consideration. To increase the likelihood of success, clinicians and administrators should follow a "SMART" (specific, measurable, achievable, relevant, time-bound) approach for the implementation of such quality improvement efforts.[48]

CONCLUSION: Aggressive surveillance is vital in understanding local factors leading to VAP and the microbiologic environment of a given unit. Judicious antibiotic usage is essential, as resistant organisms continue to plague intensive care units and critically ill patients. Simple nursing and respiratory therapy interventions for prevention should be adopted. Over the past several decades our understanding of VAP has grown significantly with regards to pathogenesis, risk factors, diagnostic testing, therapies, and prevention by modifying risk factors.

However, compliance with infection control protocols often wane overtime and can be significantly influenced by staffing levels in the ICU. Use of computerized flow sheets and quality rounding checklists in the ICU to improve compliance with care measures may help significantly. Last but not the least, despite having high grade evidence and strong recommendations, the biggest challenge remains in their actual execution into clinical practice.

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