Prevention of healthcare-associated respiratory tract infections (HA-RTI)

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Adapted from WHO Advanced Infection Prevention and Control (IPC) Training
Describe the problem of respiratory tract infections, its epidemiology and prevention
Respiratory tract

Upper respiratory tract
- Nasopharynx
- Oropharynx
- Larynx

Lower respiratory tract
- Trachea
- Bronchi/bronchioles
- Alveoli
Colonisation of the respiratory tract

• Respiratory tract (particularly upper respiratory tract) is colonised with a range of microorganisms that are part of the local flora
• Colonisation: presence of certain bacteria and viruses which live symbiotically within the host without causing harm
• Infection: pathogens cause disease
• Advantages of colonising microbes
  • Occupy available space so disease-causing pathogens have difficult penetrating (i.e. competition for survival)
  • Maintain integrity of host mucous membranes
  • Produce protective enzymes and kinases (pH maintenance) which reduce or contrast pathogenic invasion
Colonising microbes of respiratory tract

Upper respiratory tract (nares, nasopharynx):
*Staphylococcus epidermidis, S. aureus, Corynebacterium, Neisseria spp* including *N. meningitidis, Haemophilus* including *H. influenzae, Streptococcus pneumoniae*

Lower respiratory tract (trachea, bronchi and pulmonary tissues)
Usually sterile but invasion can occur from the nasopharynx:
*H. influenzae, S. pneumoniae, S. aureus, Moraxella catarrhalis*
Defences of respiratory tract against infection

- In addition to colonisation, the respiratory tract is also protected against infection by:
  - Ciliated epithelium and mucous producing goblet cells
  - Cough and clearance of mucous from lung

- When the lung is invaded, protective mechanisms are activated and immune responses of the host are stimulated (i.e. cellular and humoral immune responses)
Risk of respiratory tract infection

• With inactivity during hospital, protective mechanisms are suppressed and risk of respiratory tract infection increases

• Colonisation can also be altered by (increasing risk of respiratory tract infection):
  • Antimicrobial agents
  • Chemical irritants like, smoke and pollution
  • Foreign bodies such as endotracheal intubation
  • Immunosupression, e.g. chemical or pathology
VAP

http://jamanetwork.com/journals/jama/fullarticle/206551
Risk of VAP during endotracheal intubation

- Colonising microbes can be pushed into lower tract during intubation
- Risks of intubation:
  - Lower tract becomes colonised by bacteria
  - Aspiration of gastric contents may occur particularly in altered mental status
  - Transmission of health care associated infection (HAI) pathogens via equipment or hands may occur
Pathogenesis of VAP

Access of microbes to lower respiratory tract:
- Risks during intubation
- Biofilm (i.e. cluster of microorganisms), typically Gram-negative bacteria and fungal species within the endotracheal tube
- Pooling and trickling of secretions around the cuff
- Impairment of muco-ciliary clearance of secretions with gravity dependence of mucus flow within airways
- Pathogenic material can also collect in surrounding anatomic structures, such as the stomach, sinuses, nasopharynx and oropharynx, with replacement of normal flora by more virulent strains
Key risk factors of HA-RTI

What are key risk factors for HA-RTI?
Key risk factors of HA-RTI

- Type and duration of ventilation
- Quality of respiratory care
- Prior antibiotic use
- Previous hospitalisation
- Other patient factors

Patient risk factors for HA-RTI

- Elderly and children <5
- Pregnancy
- Pre-existing pulmonary disease
- HIV/AIDS, malignancy, chemotherapy, long term steroid use
- Diabetes, chronic liver disease, chronic kidney disease
- Malnutrition
- Prolonged hospitalizations etc. (high risk of multidrug-resistant organisms)
The mechanical ventilation lasted longer in C-ARDS than in NC-ARDS group: 16.5 [9.0–28.8] vs 9.0 [6.0–17.3] days, p<0.0001

At day 28 of ICU admission, significantly more patients developed at least one VAP episode in C-ARDS group than in NC-ARDS group: 56 (62%) vs. 35 (43%), p=0.016

### Table 1

<table>
<thead>
<tr>
<th>Variables</th>
<th>NC-ARDS (n = 82)</th>
<th>C-ARDS (n = 90)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prone position</td>
<td>34 (42%)</td>
<td>75 (83%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Neuromuscular blockade</td>
<td>53 (65%)</td>
<td>83 (92%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>First VAP</td>
<td>36 (44%)</td>
<td>58 (64%)</td>
<td>0.007</td>
</tr>
<tr>
<td>ICU length of stay among survivors, days</td>
<td>15 [10–20]</td>
<td>30 [19–45]</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
SARS-CoV-2 ARDS patients have different clinical features than other ARDS patients, characterized by more profound hypoxia, and in comparative studies, the duration of mechanical ventilation was twice as long in COVID-19 patients compared with other types of ARDS.
• less rigorous use of standard prevention strategies during COVID-19,
• disease and therapy-associated immune impairment,
• more prolonged duration of mechanical ventilation,
• prolonged use of sedation,
• more frequent need for prone ventilation,
• higher risk for pulmonary infarction with associated superinfection.
Respiratory tract infection

• Healthcare associated respiratory tract infection (HA-RTI): Any type of respiratory tract infection acquired in hospital
  • Upper respiratory tract infection (URTI): Acute infections of nose, paranasal sinuses, pharynx and/or larynx
  • Acute infections of the trachea, bronchi and/or lungs (pneumonia)
    • Hospital acquired pneumonia [HAP]: respiratory viruses, (influenza, MerCOV, RSV, measles, tuberculosis, legionella, aspergillosis
    • Ventilator associated pneumonia [VAP], Lower respiratory tract infection (LRTI)

Respiratory tract infection

- Hospital-acquired pneumonia (HAP): Pneumonia that occurs 48 hours or more after hospital admission (and that was not present at the time of admission)
- Ventilator-associated pneumonia (VAP): Pneumonia that occurs more than 48-72 hours after endotracheal intubation
  - Characterized by new or progressive infiltrate, signs of systemic infection (fever, altered white blood cell count), changes in sputum characteristics
  - Early-onset: Within 96 hours of intubation
  - Late-onset: After 96 hours of intubation, usually associated with growth of gram-negative bacilli on tracheal aspiration

Epidemiology of HA-RTI

• Associated with high mortality and morbidity
• In United States...
  • Attributable mortality (i.e. deaths that could be avoided if HAP was prevented) has been estimated to be 30-50%
  • Can increase hospital stay by an average of 7-9 days and produce an excess cost of $40,000 per patient in US

http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(10)61458-4/abstract
Incidence of HAI - respiratory infection on COVID 19 patients

HAI 59.5%
VAP 25%
HAP 9%
## VAP and mortality COVID 19 patients

<table>
<thead>
<tr>
<th></th>
<th>568 SARS-CoV2</th>
<th>482 influenza</th>
<th>526 no viral infection</th>
<th>399 (25.3%) VAP</th>
<th>167 (10.6%) VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>28-day mortality</td>
<td>28.8% (164 of 568 patients)</td>
<td>22% (125 of 482 patients)</td>
<td>32.9% (173 of 526 patients)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table of Outcomes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Comparison groups</th>
<th>HR (95%CI)</th>
<th>P-Value</th>
<th>Adjusted HR (95%CI)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Survival</td>
<td>SARS-CoV-2 vs. Influenza</td>
<td>1.08 (0.83 to 1.39)</td>
<td>0.58</td>
<td>1.38 (1.03 to 1.84)</td>
<td>0.029</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV-2 vs. No viral infection</td>
<td>0.80 (0.59 to 1.08)</td>
<td>0.14</td>
<td>1.21 (0.86 to 1.68)</td>
<td>0.027</td>
</tr>
<tr>
<td>MV duration</td>
<td>SARS-CoV-2 vs. Influenza</td>
<td>0.73 (0.60 to 0.90)</td>
<td>&lt;0.001</td>
<td>0.70 (0.59 to 0.83)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV-2 vs. No viral infection</td>
<td>0.61 (0.49 to 0.74)</td>
<td>&lt;0.001</td>
<td>0.66 (0.55 to 0.80)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Length of ICU stay</td>
<td>SARS-CoV-2 vs. Influenza</td>
<td>0.97 (0.76 to 1.24)</td>
<td>0.81</td>
<td>1.24 (0.93 to 1.63)</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV-2 vs. No viral infection</td>
<td>0.66 (0.48 to 0.91)</td>
<td>0.009</td>
<td>1.10 (0.78 to 1.55)</td>
<td>0.59</td>
</tr>
</tbody>
</table>

- **HR** (Hazard Ratio) represents the risk of an event occurring in one group compared to another.
- **P-Value** indicates the statistical significance of the difference in HR between groups.

Adjusted HR is calculated after accounting for factors that may influence the outcome, providing a more accurate comparison between groups.
Understand clinical and laboratory diagnosis of health care-associated RTI (HA-RTI)…
Diagnosis of HA-RTI

- Depending on available resources at health care facility, HA-RTI can be identified by:
  - Clinical diagnosis (e.g. diagnosis made by a practitioner)
  - Laboratory investigation (e.g. respiratory samples): Diagnosis is more specific when quantitative microbiological samples are obtained
- Rapid identification of HA-RTI are important in order to:
  - Provide appropriate antimicrobial therapy
  - Identifying patients with transmissible infections to rapidly implement IPC measures
Incidence of RTI coinfection with COVID 19

Reported incidence of

• community-acquired pulmonary bacterial coinfections with COVID-19 is as low as 3%

• 5–16% for ward and Intensive Care Units (ICU) patients respectively [1, 2].

• However, the frequency of VAP is uncertain, and its incidence, characteristics and prognosis remain to be further explored

Precautions to be used depend on Modes of transmission of HA-RTI
HA-RTI transmission routes

Key routes that HA-RTI is transmitted in health care facilities
• Droplet
• Airborne
• Other: Via contaminated equipment or hands
# Precautions and types of RTIs

<table>
<thead>
<tr>
<th>Type of Precaution</th>
<th>No pathogen identified</th>
<th>Bacterial RTI</th>
<th>TB</th>
<th>Seasonal Influenza</th>
<th>Other viruses</th>
<th>Novel RTI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Droplet</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airborne</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Contact</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

Decontamination of patient care items and equipment

• Thoroughly clean all equipment and devices to be sterilized or disinfected using manufacturer’s instructions and established protocols (e.g. *CDC Guidelines for preventing healthcare-associated pneumonia*)
• All items that come into direct or indirect contact with mucous membranes of the lower respiratory tract
  • Mechanical ventilators
  • Breathing circuits, humidifiers, heat-moisture exchanger (HME)
  • Nebulizers
  • Mistents
  • Other devices associated with respiratory therapy
  • Anesthesia machines and breathing systems or patient circuits
  • Pulmonary-function testing equipment
  • Room-air “humidifiers” and faucet aerators

Decontamination of patient care items and equipment

Challenges

• Reuse of single use items, e.g. respiratory circuits
• Soaking in open container disinfectants on the ward contaminated with MDROs
• Colonisation of linen with MDROs
Disinfection by water or water jet
Liquid chemical methods

High level disinfection

- Glutaraldehyde
- Hydrogen peroxide
- Ortho-phthaldehyde
- Peracetic acid with hydrogen peroxide
1. Elevation of the head of the bed to 30-45 degrees
2. Daily 'sedation vacation' & Daily assessment of readiness to extubate
3. Peptic ulcer disease prophylaxis,
5. Oral care with chlorhexidine (if available)

Hand hygiene is a given and a must!
Prevention reports COVID-19

- Impact of the modification of a cleaning and disinfection method of mechanical ventilators of COVID-19 patients and ventilator-associated pneumonia: One year of experience. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8451981/
- Decontamination of Mechanical ventilator with enzymatic detergent.
Prevention of VAP: Endless evolving evidences–systematic literature review

Chandrani Isac MSc Nursing | Hema Roslin Samson MSc Nursing | Anitha John MSc Nursing
Results: Evidence-based VAP preventive strategies are prevention of aspiration, minimizing ventilator days, reducing the pathogen load, safe endotracheal suction practices, and pharmaceutical preventive measures. The mandates for VAP preventive measures among coronavirus disease 2019 (COVID-19) patients is included. Conclusion: Though some of these themes identify with the past, the nuances in their implementation are highlights of this review. The review reiterates the need to revisit ambiguous practices implemented for VAP prevention. Adherence to evidence-based practices, by education, training, and reduction of workload is the key to VAP prevention.
4.1 | Preventing aspiration

The upper airway and gastrointestinal tract are with bacterial colonization. Hence, aspiration of oropharyngeal secretions predominantly

4.1.1 | Head of bed elevation [30°–45°]

Literature magnifies that head of bed elevation should be the default order for all mechanically ventilated patients. Patients with logroll protocol; pelvic fractures, morbid obesity, prone position, and intra-aortic balloon pump device are listed as some of exemptions for this intervention. Measures to promote adherence to this simple yet live saving intervention is to monitor head of bed elevation every 4 h, and to post cues in the patient rooms.⁵

4.1.2 | Draining of subglottic secretions

The drainage of secretions collected above the cuff of the endotracheal tube has significant reduction in incidence of VAP.²¹ Patients expected to require mechanical ventilation for more than 48 h are candidates for drainage of subglottic secretions. The drainage system of subglottic secretions is continuous or intermittent. Recent empirical evidence does not statistically differentiate between intermittent and continuous subglottic suctioning in terms of VAP prevention and tracheal mucosal damage. However, closed subglottic secretion drainage has significant reduction in mechanical ventilation days and ICU stay,¹⁰ and intermittent subglottic suction drainage has significant increased volume of suctioned secretion.¹⁵

4.1.3 | Maintain adequate endotracheal cuff pressure

Literature advocates maintaining endotracheal cuff pressures between 20 and 30 cmH₂O,²² with meticulous checks every 6 h,³ and with every position change.¹⁷ Patients with greater risk for VAP, require a continuous cuff-pressure control device.⁵

4.2 | Minimize ventilator days

Weaning from the ventilator follows three key steps. The first step is to reduce ventilator support as patient’s health stabilizes. The second step is to assess patient’s ability to breathe without support (spontaneous breathing trials). The third step is to extubate the patient and liberate them from the ventilator. This systematic approach in implementing weaning protocols reduces ventilator days, which can be implementation by the following empirically routed measures.

4.2.1 | Sedation interruption

Mechanically ventilated patients receiving intravenous sedation are at risk for VAP, due to depressed respiration, cough, and gag reflexes. Reviewed literature exemplifies the need to build a protocol for daily sedation interruption for mechanically ventilated patients. Daily sedation interruption (DSI) is implemented by complete or partial discontinuation of sedation medication at a fixed time, for a period of 5 h, while ensuring a Richmond Agitation Sedation Score (RASS) score between zero and two. Ventilated patients exposed to DSI had 0% VAP on their third ventilator day, compared with 15% of their counterparts with routine sedation interruption developing VAP. The decision for daily sedation interruption is contraindicated in patients with new intubation (within 24 h), escalating sedation dosages, neuromuscular blocking infusions, higher intracranial pressures, lower mean arterial blood pressure, higher fraction of inspired oxygen (FiO₂) and positive end expiratory pressure (PEEP) requirements, higher peak inspiratory airway pressure, and active seizures.

4.2.2 | Daily assessment of readiness for extubation

Protocolized sedation interruption paves the way for early extubation. Non-sedated patients with RASS scores between zero and two, vital signs and saturation greater than 90%, lower requirements for FiO₂ (≤0.5), and PEEP < 8cmH₂O are good candidates for extubation.

4.3 Reducing the pathogen load

Migration of the bacteria colonized in the upper respiratory tract and gastrointestinal tract to lower airways of the lung increases VAP incidence. Empirical ventures report oral care with chlorhexidine gluconate 0.12% solution every 2–4 h, and tooth brushing every 12 h to reduce pathogen load. These ventures reduced VAP incidence from 144 between 2008 and 2010; to 14 between 2011 and 2013. The provision of oral care with suction tooth brush and chlorhexidine mouth rinses every 4 h for ventilated patients reduced the VAP incidence from 12 in the baseline period to 3 in the intervention period.

4.4 Safe endotracheal suction practices

Endotracheal suctioning involves the insertion of a catheter into the airway for removing the retained tracheobronchial secretions. Employing safe techniques prevents the introduction of infectious agents. Evidence-based safe practice standards, that remains undebated includes:

- Endotracheal suctioning is performed only when necessary.
- Preoxygenation is considered in patients having clinically significant reduction in oxygen saturation with suctioning.
- The suction catheter should occlude less than half of the lumen of the endotracheal tube.
- Suctioning pressure maintained between 80 and 150 mmHg.
- A suction pass no longer than 15 seconds.
- No routine instillation of normal saline.
- Suction pressures not to exceed 150 mmHg.
- Strict aseptic technique.

Few of the endotracheal suction practices expose themselves to frequent debate and are tested and restated in literature. The ambivalence between shallow and deep suctioning is clarified by recent evidence, which states that hemodynamic and respiratory parameters significantly increase in both methods; however, the frequency of suctioning increased with shallow suction. Similarly, the preference between open and closed suctioning techniques is inconclusive. The occurrence of VAP was 12 in the group with open tracheal suction system, and 10 in the group with closed tracheal suction system, with no significant difference between them. Closed suction is suggested for adults with high FiO₂, or PEEP requirements, and those requiring lung de-recruitment.
4.5 Pharmaceutical preventive measures

Ventilated patients are at risk for stress ulcers, and prescribed acid suppressive medications prophylactically. These medications raise the pH of the gastric fluids, allowing bacterial overgrowth. Sucralfate, a viscous paste of aluminum binds to gastric ulcers forming a direct protective barrier for 6 h. A meta-analysis with data surveyed between 1996 and 2013, reports that VAP incidences significantly reduced in ventilated patients receiving sucralfate. Reviewed literature documents that insulin resistance causing; a hyperglycemic state precedes the onset of VAP. Hence, hypothe-
ically glycemic control will prevent VAP. The institution of MIAR (measure, interpret, act, and reanalysis) is recommended for effective glycemic control.

VAP preventive measures is not limited to the interventions broadcasted above. Multiple interventions as a "bundle of care" is required for VAP prevention. A systematic approach is required to choose the interventions, which is most feasible, suitable and effective. Speck et al. (2016), through their rigorous exploration using the modified Delphi technique, identified a comprehensive list of 5 process and 14 structural-driven interventions for VAP prevention.
4.6 VAP prevention protocol in the context of COVID-19

The COVID-19 pandemic has escalated the prevalence of ventilated patients and the rigor for VAP prevention is mandated. World Health Organization recommends the implementation of the following standards for VAP prevention among COVID-19 patients:

- Preference for oral instead of nasal intubation (adults and adolescents).
- Closed suctioning system, periodically drain and discard condensate in tubing.
- Keep patients in semirecumbent position (head-bed elevated 30°–45°).
- A new ventilator circuit for each patient, change circuit only if soiled or damaged.
- Change heat moisture exchanger, when soiled or every 5–7 days.

Additional references


Centers for Disease Control and Prevention (CDC): 2003 Guidelines for preventing healthcare associated pneumonia


Institute of Healthcare Improvement How-to Guide: Prevent Ventilator-Associated Pneumonia
http://www.ihi.org/resources/Pages/Tools/HowtoGuidePreventVAP.aspx

Prevention of hospital-acquired pneumonia in non-ventilated adult patients: a narrative review
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5109660/
Thanks