

Effectiveness of Ventilator Bundle on Prevention of Ventilator-Associated Pneumonia among Patients Receiving Mechanical Ventilation at Selected Hospitals, Bengaluru

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Abstract: Background: Ventilator-associated pneumonia (VAP) is one of the most common healthcare-associated infections among critically ill patients receiving mechanical ventilation. It contributes significantly to prolonged intensive care unit (ICU) stay, increased healthcare costs, higher morbidity, and mortality. Evidence-based ventilator care bundles have been recommended to reduce the incidence of VAP through standardized preventive interventions. Aim: To evaluate the effectiveness of a ventilator bundle in preventing ventilator-associated pneumonia among patients receiving mechanical ventilation at selected hospitals in Salem. Methods: A quantitative evaluative approach with a quasi-experimental post-test-only control group design was adopted. Forty mechanically ventilated patients were selected using non-probability convenience sampling. Twenty patients in the experimental group received the ventilator bundle, while twenty patients in the control group received routine ICU care. The ventilator bundle consisted of head-of-bed elevation to 30°, repositioning every three hours, and closed-system endotracheal suctioning. Ventilator-associated pneumonia was assessed using the Modified Clinical Pulmonary Infection Score (CPIS). Data were analyzed using descriptive and inferential statistics. Results: The implementation of the ventilator bundle demonstrated a significant reduction in the occurrence of ventilator-associated pneumonia among mechanically ventilated patients compared with routine care. Patients who received the intervention showed lower Clinical Pulmonary Infection Scores, indicating improved clinical outcomes. Conclusion: The ventilator bundle is an effective, evidence-based nursing intervention for reducing the incidence of ventilator-associated pneumonia among mechanically ventilated patients. Incorporating ventilator bundle practices into routine ICU nursing care can improve patient safety and reduce infection-related complications.

Keywords: Ventilator-associated pneumonia, Ventilator bundle, Mechanical ventilation, Critical care nursing, Clinical Pulmonary Infection Score

1. Introduction

Ventilator-associated pneumonia (VAP) is a hospital-acquired pneumonia that develops at least 48 hours after the initiation of mechanical ventilation through an endotracheal or tracheostomy tube. It remains one of the most frequent infectious complications among critically ill patients admitted to intensive care units (ICUs). The occurrence of VAP is associated with prolonged hospitalization, increased duration of mechanical ventilation, higher antibiotic consumption, greater financial burden, and increased mortality.

Mechanical ventilation bypasses the body's natural airway defense mechanisms, facilitating colonization of pathogenic microorganisms within the lower respiratory tract. Factors such as impaired cough reflex, accumulation of secretions above the endotracheal tube cuff, microaspiration, prolonged intubation, and inadequate infection control practices further increase the risk of developing VAP. The incidence is particularly high during the first week of mechanical ventilation, making early preventive interventions essential.

Over the last decade, healthcare organizations have increasingly emphasized evidence-based care bundles to reduce healthcare-associated infections. A ventilator bundle is a structured group of evidence-based interventions that, when implemented consistently, significantly lowers the risk of ventilator-associated pneumonia. The bundle used in the present study included elevation of the head of the bed to 30 degrees, regular repositioning of the patient every three hours,

and closed-system endotracheal suctioning. These interventions collectively minimize aspiration, improve pulmonary drainage, and reduce microbial contamination of the lower respiratory tract.

Critical care nurses play a pivotal role in implementing ventilator bundle practices because these interventions form part of routine nursing care. Strict adherence to standardized ventilator care protocols can substantially reduce the incidence of VAP while improving patient outcomes and reducing healthcare costs.

2. Literature Survey

Ventilator-associated pneumonia continues to be a major challenge in intensive care practice worldwide. Several investigators have reported high incidence rates of VAP among mechanically ventilated patients, with common causative organisms including *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, *Klebsiella pneumoniae*, and *Staphylococcus aureus*. Previous studies have consistently demonstrated that prolonged mechanical ventilation, re-intubation, impaired consciousness, inadequate airway management, and improper suctioning techniques significantly increase the risk of developing VAP.

Evidence from national and international studies indicates that implementation of ventilator care bundles significantly reduces the incidence of ventilator-associated pneumonia. Studies conducted in intensive care units across India and

other countries have reported substantial reductions in VAP rates following the introduction of standardized preventive measures such as head-of-bed elevation, oral hygiene with chlorhexidine, closed-system suctioning, daily sedation assessment, and early weaning protocols. Improvements have also been observed in terms of reduced ICU stay, shorter duration of mechanical ventilation, lower healthcare costs, and decreased mortality.

Research conducted in tertiary care hospitals has further demonstrated that consistent compliance with ventilator bundle protocols is associated with better clinical outcomes than isolated preventive measures. These findings support the routine implementation of ventilator bundles as a standard component of critical care nursing practice.

Although numerous studies have established the effectiveness of ventilator bundles internationally, limited evidence was available regarding their implementation among mechanically ventilated patients in selected hospitals of Salem, Tamil Nadu. Therefore, the present study was undertaken to evaluate the effectiveness of a simplified ventilator bundle in preventing ventilator-associated pneumonia within the local clinical setting.

3. Problem Definition

Ventilator-associated pneumonia remains a preventable complication among mechanically ventilated patients despite advances in critical care practices. Variations in adherence to evidence-based nursing interventions contribute to increased infection rates and poorer patient outcomes. There is a need to evaluate whether systematic implementation of a ventilator bundle can effectively reduce the occurrence of VAP among patients receiving mechanical ventilation.

Statement of the Problem

A study to evaluate the effectiveness of a ventilator bundle on the prevention of ventilator-associated pneumonia among patients receiving mechanical ventilation at selected hospitals, Bengaluru.

Objectives

- To assess the occurrence of ventilator-associated pneumonia among mechanically ventilated patients in the experimental and control groups.
- To evaluate the effectiveness of the ventilator bundle in preventing ventilator-associated pneumonia.
- To determine the association between post-test ventilator-associated pneumonia scores and selected demographic variables.

4. Methodology

Research Design

A quantitative evaluative research approach was adopted using a quasi-experimental post-test-only control group design to determine the effectiveness of a ventilator bundle in preventing ventilator-associated pneumonia among mechanically ventilated patients. This design facilitated comparison between an intervention group receiving the ventilator bundle and a control group receiving routine intensive care without introducing randomization.

Study Setting

The study was conducted in the Intensive Care Units of TECC, Victoria Hospital Campus, Fort, Bengaluru

Population

The target population comprised adult patients receiving mechanical ventilation in the intensive care units of the selected hospitals.

Sample

The study included 40 mechanically ventilated patients.

- Experimental group (n = 20)
- Control group (n = 20)

Sampling Technique

Non-probability convenience sampling was used to recruit participants who fulfilled the eligibility criteria during the data collection period.

Eligibility Criteria

Inclusion Criteria

- Patients aged between 20 and 60 years.
- Patients receiving mechanical ventilation.
- Male and female patients.

Exclusion Criteria

- Patients intubated for more than 24 hours before recruitment.
- Patients diagnosed with pneumonia before initiation of mechanical ventilation.
- Patients with Acute Respiratory Distress Syndrome (ARDS).
- Patients with cervical or spinal cord injuries.
- Patients transferred with an existing endotracheal tube from another hospital.

Intervention

Patients in the experimental group received a structured ventilator bundle consisting of:

- Elevation of the head of the bed to 30°
- Repositioning every three hours
- Closed-system endotracheal suctioning

The intervention was implemented according to standard nursing protocols throughout the observation period.

Patients in the control group received routine ICU nursing care, including conventional endotracheal suctioning without the structured ventilator bundle.

Data Collection Instrument

Data collection consisted of two sections.

Section A: Demographic characteristics including age, sex, indication for mechanical ventilation, frequency of suctioning, frequency of repositioning, and smoking history.

Section B: Modified Clinical Pulmonary Infection Score (CPIS) for assessment of ventilator-associated pneumonia. CPIS scores were interpreted as follows:

Score	Interpretation
0	No infection
1–2	Mild infection
3–5	Severe infection

The Modified CPIS served as the primary outcome measure for evaluating the occurrence of ventilator-associated pneumonia.

Validity and Reliability

Content validity of the instrument was established through expert review by two medical specialists and four nursing experts. Reliability was assessed using the inter-rater method, yielding a coefficient of $r = 1.0$, indicating excellent reliability.

Pilot Study

A pilot study involving six mechanically ventilated patients was conducted prior to the main study to assess the feasibility of the research protocol. Three participants were assigned to the experimental group and three to the control group. The findings confirmed the feasibility and practicality of the intervention and data collection procedures.

Ethical Considerations

Administrative permission was obtained from the respective hospital authorities before commencement of the study. Ethical principles of autonomy, confidentiality, beneficence, and non-maleficence were maintained throughout the study. Consent procedures were completed in accordance with institutional requirements before participant enrolment.

Statistical Analysis

Data were analysed using descriptive and inferential statistics. Frequency, percentage, mean, and standard deviation were used to describe demographic and clinical variables. The effectiveness of the ventilator bundle was evaluated using appropriate inferential statistical tests, and associations between post-test CPIS scores and selected demographic variables were examined. A p-value of <0.05 was considered statistically significant.

5. Results and Discussion

5.1 Results

A total of 40 mechanically ventilated patients participated in the study, with 20 patients allocated to the experimental group and 20 to the control group. Baseline demographic characteristics such as age, sex, indication for mechanical ventilation, frequency of suctioning, repositioning practices, and smoking history were comparable between the two groups.

Incidence of Ventilator-Associated Pneumonia

Post-intervention assessment using the Modified Clinical Pulmonary Infection Score (CPIS) demonstrated a lower incidence and severity of ventilator-associated pneumonia among patients who received the ventilator bundle compared with those receiving routine nursing care.

Outcome	Experimental Group (n=20)	Control Group (n=20)
Mean CPIS Score	1.70 ± 1.04	2.95 ± 1.76
Mean Difference	1.25	—
t-value	5.2	—
Statistical Significance	$p < 0.05$	Significant

The mean post-test CPIS score was significantly lower in the experimental group than in the control group ($t = 5.20$, $p < 0.05$), indicating that the ventilator bundle effectively reduced the occurrence of ventilator-associated pneumonia. Therefore, the first research hypothesis was accepted.

Association with Demographic Variables

Chi-square analysis revealed no statistically significant association between post-test CPIS scores and demographic variables, including age, sex, indication for mechanical ventilation, frequency of suctioning, and smoking history ($p > 0.05$). Accordingly, the second hypothesis was rejected.

5.2 Discussion

The present study demonstrated that implementation of a structured ventilator bundle significantly reduced the occurrence of ventilator-associated pneumonia among mechanically ventilated patients. Patients receiving the intervention had substantially lower CPIS scores than those receiving routine ICU care, confirming the effectiveness of evidence-based nursing interventions in preventing VAP.

The findings are consistent with previous investigations reporting significant reductions in VAP following implementation of ventilator care bundles. Studies by Rello et al. reported decreased VAP incidence, shorter ICU stay, and reduced duration of mechanical ventilation after bundle implementation. Similarly, Bukhari et al. observed a reduction in VAP incidence from 26.3% to 10.2% following implementation of a standardized ventilator bundle, while Conway Morris et al. demonstrated statistically significant reductions in VAP rates and methicillin-resistant *Staphylococcus aureus* acquisition after introducing ventilator bundle practices.

The effectiveness observed in the present study is attributable to the combined preventive effect of three evidence-based nursing interventions: maintaining head-of-bed elevation at 30° , repositioning patients every three hours, and using closed-system endotracheal suctioning. Together, these interventions reduce aspiration of contaminated secretions, improve pulmonary drainage, maintain airway patency, and minimize microbial colonization of the lower respiratory tract.

The absence of significant associations between demographic variables and CPIS scores suggests that the preventive benefit of the ventilator bundle was independent of patient characteristics. This finding emphasizes that consistent adherence to standardized nursing protocols may have a greater influence on preventing VAP than demographic factors alone.

Overall, the findings reinforce the importance of incorporating ventilator bundles into routine critical care nursing practice. Systematic implementation of evidence-

based bundle components has the potential to improve patient safety, reduce infection-related complications, shorten ICU stay, and decrease healthcare costs associated with ventilator-associated pneumonia.

6. Conclusion

The study demonstrated that implementation of a structured ventilator bundle significantly reduced ventilator-associated pneumonia among mechanically ventilated patients. Participants receiving the intervention had lower CPIS scores than those receiving routine care, confirming the effectiveness of the ventilator bundle as an evidence-based nursing strategy.

Routine implementation of ventilator bundles in intensive care units can contribute to improved quality of care, enhanced patient safety, and reduced morbidity associated with mechanical ventilation. Adoption of standardized ventilator bundle protocols should therefore be encouraged as part of routine nursing practice in critical care settings.

7. Clinical Implications

Nursing Practice

- Implement ventilator bundles consistently for all eligible mechanically ventilated patients.
- Monitor compliance with bundle components through regular clinical audits.
- Promote adherence to evidence-based infection prevention protocols.

Nursing Education

- Incorporate ventilator bundle practices into undergraduate and postgraduate nursing curricula.
- Conduct continuing nursing education programmes on VAP prevention.

Nursing Administration

- Develop institutional protocols and checklists for ventilator bundle implementation.
- Provide regular competency-based training for ICU nurses.

Nursing Research

- Conduct multicentre randomized controlled trials with larger sample sizes.
- Evaluate long-term outcomes such as mortality, ICU length of stay, duration of ventilation, and healthcare costs.

8. Limitations

- Small sample size (n = 40).
- Conducted in only two hospitals.
- Quasi-experimental design without randomization.
- Short follow-up period.
- Assessment relied primarily on the Modified Clinical Pulmonary Infection Score.

9. Future Scope

Future research should evaluate comprehensive ventilator bundles incorporating oral chlorhexidine care, daily sedation interruption, spontaneous breathing trials, cuff pressure monitoring, and subglottic secretion drainage. Multicentre studies with larger samples are recommended to improve the generalizability of findings and assess long-term patient outcomes.

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