Research Article

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EFFECTIVENESS OF VENTILATOR BUNDLE ON PREVENTION OF VENTILATOR ASSOCIATED PNEUMONIA AMONG CHILDREN ON MECHANICAL VENTILATOR AT PEDIATRIC INTENSIVE CARE UNIT, GRH, MADURAI.

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) is one of the most common hospital-acquired infections in Pediatric Intensive Care Units (PICUs), contributing significantly to morbidity, mortality, prolonged hospital stay, and increased healthcare costs. **Aim:** To evaluate the effectiveness of a ventilator bundle in preventing ventilator-associated pneumonia among children on mechanical ventilation in the PICU at GRH, Madurai. **Materials and Methods:** A quantitative evaluative approach with a quasi-experimental control group posttest-only design was adopted. Sixty children on mechanical ventilation (30 intervention, 30 control) were selected using consecutive sampling. The intervention group received the ventilator bundle, including head-end elevation, position change, oral care with normal saline, and suctioning, while the control group received routine care.. **Results:** In the intervention group, 76.7% of children had no infection and 23.3% had mild infection, whereas in the control group only 23.3% had no infection, 53.4% had mild infection, and 23.3% had moderate infection ($\chi^2 = 19.055$, $p = 0.000$). The mean ventilator score of the intervention group (0.27 ± 0.521) was significantly lower than that of the control group (2.07 ± 1.461), with a mean difference of 1.80 ($t = 6.358$, $p = 0.000$). **Conclusion:** The study concluded that the ventilator bundle was highly effective in reducing ventilator-associated pneumonia among children in the PICU.

Keywords: Ventilator-associated pneumonia, ventilator bundle, pediatric intensive care, mechanical ventilation, prevention.

INTRODUCTION:

Child health encompasses physical, mental, intellectual, social, and emotional well-being, allowing children to reach their full developmental potential within supportive families, environments, and communities. Biologically, a child is defined from birth to puberty, while legally, it typically refers to a minor. Childhood diseases affect individuals from the fetal stage through adolescence.

Respiratory diseases are a leading global cause of mortality and morbidity, particularly in infants and young children. Key conditions include acute respiratory infections, chronic obstructive pulmonary disease, asthma, tuberculosis, and lung cancer. Pneumonia is the primary cause of childhood mortality, with many cases preventable through childhood immunization, which also benefits the elderly. Asthma is the most common chronic non-communicable disease in children, and pediatric tuberculosis represents a significant portion of the global TB burden in high-incidence countries. Environmental factors like tobacco smoke, indoor air pollution, and poor nutrition are significant risk factors for both acute and chronic respiratory diseases, with early childhood exposures potentially leading to adult chronic conditions.

Endotracheal intubation (ETI) is a critical skill for physicians managing critically ill pediatric patients. Indications include lower airway obstruction, hypercarbia, tachypnea, increased work of breathing, wheezing, and prolonged expiratory phases, often seen in asthma and bronchiolitis. However, intubation in children due to these conditions should be reserved for extreme circumstances due to the risk of increased mean airway pressure impeding venous return. Mechanical ventilation, using a mechanical ventilator, is employed to control respiration during surgery, treat severe head injury, or provide oxygenation when a patient's breathing efforts are insufficient.

Pneumonia acquired during mechanical ventilation (VAP) has specific causative agents depending on its onset. Early-onset VAP is typically caused by Staphylococcus aureus, Haemophilus influenza, and Streptococcus pneumoniae, while late-onset VAP is linked to Methicillin-Resistant Staphylococcus Aureus, Pseudomonas aeruginosa, and Acinetobacter or Enterobacter. VAP is characterized by new or progressive infiltrates on chest X-ray, purulent sputum, fever, leukocytosis, and positive cultures, and is directly related to hospital procedures and prevailing bacterial flora.

The Centers for Disease Control and Prevention define VAP as hospital-acquired pneumonia developing in patients ventilated for at least 48 hours who had no prior lower respiratory infection symptoms. VAP occurrence in pediatric intensive care units (PICUs) is reported at 6–10% of ventilated patients, with an incidence of 6–13 episodes per 1000 ventilator days. VAP is a major health risk in PICUs, contributing significantly to hospital-acquired infections and associated with elevated mortality (around 10–20%),

morbidity, prolonged hospital stays, and increased healthcare costs. Incidence rates are higher in developing countries.

Preventing VAP is a crucial safety concern. The American Association of Critical-Care Nurses recommends implementing a "ventilator bundle," a set of evidence-based interventions performed collectively to reduce VAP rates and improve patient outcomes. These bundles, typically comprising three to five evidence-based practices, aim to improve care processes and outcomes through consistent application of well-established practices. Implementing a pediatric ventilator bundle is considered a practical, safe, and multidisciplinary approach for better patient and clinical outcomes, demonstrated to significantly reduce VAP rates, duration of mechanical ventilation, antibiotic use, PICU stay, and hospital costs.

NEED FOR THE STUDY

Ventilator-associated pneumonia (VAP) is a major cause of hospital-acquired infections in Pediatric Intensive Care Units (PICUs), accounting for 18–26% of all nosocomial infections and contributing significantly to morbidity, mortality, and healthcare costs. Despite improvements in aseptic techniques, antibiotic therapy, and supportive care, the incidence of VAP remains high, ranging globally from 1.7 to 17 per 1000 ventilator days, with marked variation across countries. In the United States, the CDC reported a rate of 2.9 per 1000 ventilator days, while Canada noted 10.6 cases per 1000 ventilator days with an estimated 4000 cases and 230 deaths annually, costing about CAD 46 million. In Korea, the incidence ranges from 3.5 to 7.1 per 1000 ventilator days, while Egyptian hospitals report rates as high as 75%. In India, the incidence varies widely, from 8.95 to 24 per 1000 ventilator days, with some studies showing 17–30% and others up to 53–58%, highlighting the burden in developing countries. Risk factors in children include prolonged mechanical ventilation, re-intubation, aspiration, enteral feeding, transport out of PICU, genetic syndromes, and use of contaminated equipment, while common pathogens include Pseudomonas spp., Staphylococcus aureus, and Gram-negative bacilli. VAP increases ICU stay by about 4.3 days per episode, with mortality ranging from 25–45%. Although no universally accepted paediatric prevention bundle exists, studies show that selective interventions such as strict hand hygiene, semi-recumbent positioning, chlorhexidine oral care, and maintaining endotracheal tube cuff pressure can significantly reduce incidence, with nurses playing a crucial role in implementation. Therefore, VAP remains a preventable but devastating complication in PICUs, emphasizing the urgent need for standardized paediatric protocols to reduce hospital stay, cost, morbidity, and mortality.

AIM OF THE STUDY:

The aim of the study to evaluate the effectiveness of ventilator bundle on prevention of ventilator associated pneumonia among children on mechanical ventilator at Pediatric Intensive Care Unit, GRH, Madurai.

MATERIALS AND METHODS

Study Design and Participants

A quantitative evaluative approach with a quasi-experimental control group posttest-only design was used. Sixty children on mechanical ventilation in the PICU, GRH, Madurai, were selected (30 intervention, 30 control) through consecutive sampling.

Inclusion and Exclusion Criteria

Inclusion: children aged 1 month–12 years, on the first day of intubation.

Exclusion: children with cervical/spinal cord injury or pneumonia at admission.

Tools

The tool included: Section A (socio-demographic variables), Section B (clinical variables), and Section C (Clinical Pulmonary Infection Score – CPIS). CPIS classified VAP as none (0), mild (1–3), moderate (4–6), or severe (7–10). Validated by experts and found reliable ($r = 0.76$).

Ethical Clearance

Ethical approval was obtained from the Institutional Ethical Committee, Madurai Medical College. Written and verbal informed consent was taken from caregivers, ensuring confidentiality and voluntary participation.

Data Collection Procedure

The study was conducted from 04.07.2022 to 14.08.2022. The intervention group received the ventilator bundle (head-end elevation, position change, oral care, suctioning) every 4 hours for 3 days; both groups were assessed on the 4th day using CPIS.

Data Analysis

Descriptive statistics (frequency, percentage) were used for demographic and clinical variables. Unpaired t-test measured bundle effectiveness, and chi-square test identified associations with selected variables.

RESULTS:

Socio-demographic Variables

In the intervention group, most children were below 1 year (30%) or aged 3–12 years (53.4%), while in the control group, the majority were 6–12 years (40%). Gender distribution was equal in the intervention group (50% each), whereas males were slightly more in the control group (56.7%). With respect to domicile, most children in the intervention group were from semi-urban areas (40%), while in the control group, half were from rural areas (50%). Regarding siblings, 46.7% in the intervention group had none, while in the control group, 50% had one sibling. Family income in both groups was mainly Rs. 5,001–10,000 (46.7%). In terms

of water supply, corporation water (36.7% vs. 40%) and mineral water (33.3% vs. 36.7%) were commonly used in both groups. With respect to pet ownership, dogs were most common in the intervention group (33.3%), while in the control group, 36.7% had no pets, followed by dogs (26.6%) and birds (16.7%). (Table1)

Clinical Variables

In the intervention group, 30% were infants and 26.7% each preschooler and schoolers, while in the control group 40% were schoolers and 20% infants. Normal vaginal delivery was more frequent (63.4% vs. 46.7%), with most births in government hospitals (43.3% vs. 46.7%). Almost all children cried immediately after birth (86.7% vs. 83.3%). First-degree malnutrition was common in both groups (70%), while some dehydration was more frequent in controls (53.4% vs. 33.3%). Most had prior medical treatment (60% vs. 53.3%), and pneumococcal vaccination coverage was equal (73.3%). All were orally intubated, mostly with uncuffed tubes (83.3% vs. 76.7%), and SIMV was the predominant ventilator mode (46.7% vs. 43.4%). Daily suction needs were mainly 4–8 times, with clear secretions more common in intervention (76.7% vs. 50%) and yellow/brown secretions more in control (50%). Watery, non-odorous secretions predominated in both groups, and nutrition was mainly IV fluids with NG feeding (53.3% vs. 53.4%).

Level of ventilator associated pneumonia:

In the intervention group, 76.7% of children had no infection and 23.3% had mild infection, while in the control group only 23.3% had no infection, 53.4% had mild infection, and 23.3% had moderate infection. None in either group developed severe infection. The chi-square test ($\chi^2 = 19.055$, $p = 0.000$) showed a highly significant difference (VHS***) between groups, indicating that the ventilator bundle was effective in reducing ventilator-associated pneumonia. (Table 2)

Comparison of Mean score:

The mean ventilator score of the intervention group (0.27 ± 0.521) was significantly lower than that of the control group (2.07 ± 1.461), with a mean difference of 1.80. The calculated 't' value ($t = 6.358$) at $p = 0.000$ indicates a statistically highly significant difference (VHS***) between the two groups, showing that the ventilator bundle was effective in reducing ventilator-associated pneumonia among children. (Table 3)

Table 1: Sociodemographic variables of children on mechanical ventilator (n = 60)

Socio-demographic Variables	Intervention Group (n=30)	Control Group (n=30)
Age	f (%)	f (%)
< 1 year	9 (30)	6 (20)
1 – 3 years	5 (16.6)	5 (16.7)
3 – 6 years	8 (26.7)	7 (23.3)

6 – 12 years	8 (26.7)	12 (40)
Gender		
Male	15 (50)	17 (56.7)
Female	15 (50)	13 (43.3)
Place of domicile		
Urban	9 (30)	8 (26.7)
Semi-urban	12 (40)	7 (23.3)
Rural	9 (30)	15 (50)
Number of siblings		
Nil	14 (46.7)	10 (33.3)
One	10 (33.3)	15 (50)
Two and above	6 (20)	5 (16.7)
Monthly family income		
< Rs. 5000	5 (16.7)	5 (16.7)
Rs. 5001 – 10,000	14 (46.7)	14 (46.7)
Rs. 10,001 – 15,000	9 (30)	7 (23.3)
Above Rs. 15,000	2 (6.6)	4 (13.3)
Water supply		
Corporation	11 (36.7)	12 (40)
Well water	4 (13.3)	2 (6.6)
Mineral water	10 (33.3)	11 (36.7)
Bore well water	5 (16.7)	5 (16.7)
Pet animals		
No pets	9 (30)	11 (36.7)
Fish	4 (13.3)	3 (10)
Birds	1 (3.4)	5 (16.7)
Dogs	10 (33.3)	8 (26.6)
Cat	6 (20)	3 (10)

Table 2: Frequency and percentage distribution of posttest level of ventilator associated pneumonia among children on mechanical ventilator in intervention group and control group. n = 60

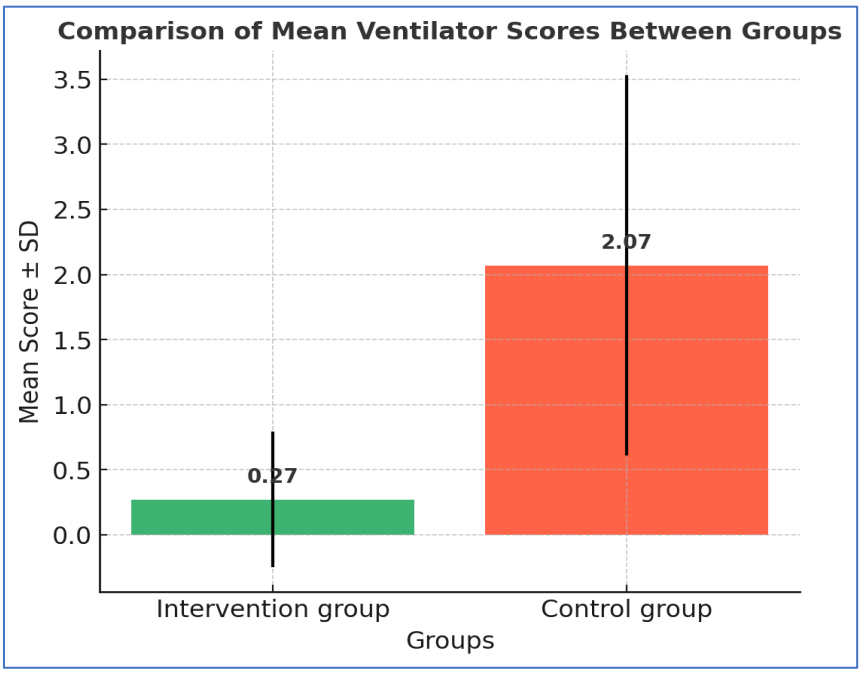
Ventilator associated pneumonia	Posttest				Chi-Square & p-value
	Intervention Group		Control Group		
	f	%	f	%	
No infection (0)	23	76.7	7	23.3	$\chi^2 = 19.055$ P = 0.000 VHS***
Mild (1 – 3)	7	23.3	16	53.4	
Moderate (4 – 6)	0	0	7	23.3	
Severe (7 – 10)	0	0	0	0	

*p<0.05, S-Significant

Table 3: Comparison of the mean score of mechanical ventilators between the intervention group and control group. n = 60

Group	Mean	SD	Mean Difference Score	Student Independent 't' and p-value
Intervention group	0.27	0.521	1.80	t = 6.358 p=0.000 VHS***
Control group	2.07	1.461		

*p<0.05, S-Significant



DISCUSSION:

The study results showed that the ventilator bundle was effective in reducing ventilator-associated pneumonia among children on mechanical ventilation. In the intervention group, 76.7% of children had no infection and 23.3% had mild infection, whereas in the control group only 23.3% had no infection, 53.4% had mild infection, and 23.3% had moderate infection. None in either group developed severe infection. The chi-square test (χ^2 = 19.055, p = 0.000) revealed a highly significant difference between the groups. Similarly, the mean ventilator score of the intervention group (0.27 ± 0.521) was significantly lower than that of the control group (2.07 ± 1.461), with a mean difference of 1.80. The independent 't' test value (t = 6.358, p = 0.000) also confirmed a highly significant difference, indicating that the ventilator bundle markedly reduced the incidence of ventilator-associated pneumonia among children in the PICU.

The findings of this study are in line with research by Boville et al. (2012), who conducted an experimental study in pediatric ICUs to evaluate the impact of ventilator bundle implementation and compliance monitoring on VAP incidence. Data collected over six months showed a marked reduction in VAP rates following the intervention, with cases decreasing from 7.6 to 2.0 per 1000 ventilator days, a difference that was statistically significant ($p < 0.001$).

CONCLUSION:

The study demonstrated that the ventilator bundle was highly effective in reducing ventilator-associated pneumonia among children in the PICU, with significantly lower infection rates and mean scores in the intervention group. Adoption of such bundles can minimize morbidity and improve outcomes in critically ill children.

RECOMMENDATION:

A similar study can be replicated with a larger sample size to enhance generalization of the findings. Further research may also focus on assessing the knowledge, skills, and attitudes of nursing staff regarding ventilator bundle practices. In addition, such studies can be extended to other settings, including neonatal intensive care units and surgical intensive care units, to evaluate the broader effectiveness of ventilator bundle interventions.

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