Prevention of Ventilator-Associated Pneumonia in Pediatric Intensive Care Unit

Thesis

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By
Samah Ahmed Hassnean

Under supervision of

Prof. Dr. Nabil Abd EL Aziz Mohsen
Professor of Pediatrics
Faculty of Medicine
Cairo University

Dr. Osama Mohamed Abd EL Aziz
Lecturer of Pediatrics
Faculty of Medicine
Cairo University

Dr. Hanaa Ibrahim Rady
Lecturer of Pediarics
Faculty of Medicine
Cairo University

Faculty of Medicine
Cairo University
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List of Abbreviation

A/C	Assist –control
BAL	Bronchoalveolar lavage
CA-MRSA	Community acquired-Methicillin resistant staphylococcus auras
CDC	Centers of Disease Control and Prevention
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CMV	Continuo mandatory ventilation
CONS	Coagulase negative staphylococcus aueus
CPAP	Continuous positive airway pressure
CPIS	Clinical pulmonary infection score
CPIS	Clinical Pulmonary Infection Score
CXR	Chest x ray
ESBLs	Extended spectrum B-lactamases
ETT	Endotracheal tube
FDA	Food and drug American Association
FRC	Functional residual capacity
HAI	Hospital acquired infection
HA-MRSA	Hospital acquired-Methicillin resistant staphylococcus auras
HCU	High- care unit
HDUs	High-density units
HIV	Human immunodeficiency virus
HOB	Head of bed
ICU	Intensive care unit
IMV	Intermittent mandatory ventilation
MDR	Multi-drug resistant
MRSA	Methicillin-Resistant Staphylococcus Auras
NI	Nosocomial infection
NIPPV	Non invasive positive pressure ventilation
NNIS	National Nosocomial Infection Surveillance system
PEEP	Positive end expiratory pressure
PICU	Pediatric intensive care unit
PPV	Positive pressure ventilation
PSB	Protected specimen brush
SDD	Selective decontamination of the digestive tract
SICU	Surgical intensive care unit
SIMV	Synchronized intermittent mandatory ventilation
SSD	Subglottic secretion drainage
TICU	Trauma Intensive Care Unit
VAP	Ventilator-associated pneumonia
VISA	Vancomycin-intermediate staphylococcus auras
VRSA	Vancomycin-resistant staphylococcus auras

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Introduction

Ventilator-associated pneumonia (VAP) is defined as pneumonia in mechanically ventilated patients that develops later than or at ٤٨ hrs after the patient has been placed on mechanical ventilator. It is the second most common hospital–acquired infection among pediatric and neonatal intensive care patients occurring in ٦% to ٥٢% of ventilated pediatric intensive care unit (PICU) patients ***(Fogelia, et al., ٢٠٠٧)***

VAP is associated with increased morbidity and mortality in PICU patients. It is the leading cause of death among hospital–acquired infections in the intubated patients. Hospital mortality in ventilated patients who develops VAP is ٤٦ %, compared to ٣٢٪ for ventilated patient who do not develop VAP along the duration of mechanical ventilation. Moreover, VAP adds an estimated cost of $ ٤٠,٠٠٠ to a typical hospital admission ***(Ibrahim, et al., ٢٠٠١)***

VAP is diagnosed in patients who are mechanically ventilated for more than or equal to ٤٨ hrs and have developed abnormal chest radiography with either one of the following symptoms: fever (٣٨ or more) with no other recognized cause, leucopenia (٤,٠٠٠\mm^{٢} or less), leucocytosis (١٣,٠٠٠\mm ^{٢}or more). In addition, patients should have at least two changes either in the sputum character, respiratory secretions, cough or worsening of gas exchange (O$_{٢}$ desaturation, increased O٢ requirements or increased ventilation demand) ***(Cordero, et al., ٢٠٠٢)***

The risk factors for developing VAP were found to be genetic syndromes, transport out of the PICU, re-intubation, prior antibiotic use, continuous enteral feeding, bronchoscope, immunosuppressants, immunodeficiency, neuromuscular blockade, some medications such as steroids and H٢ blockers. The most commonly isolated organisms in

VAP were staphylococcus aures and pseudomonas aeurogenosa ***(Elward, et al., ٢٠٠٢)***

Because of higher incidence and costs of VAP, there are several recommendations to decrease it. The health care infection control practices advisory committee suggests using oro-tracheal tubes instead of naso-tracheal tubes when the patients require mechanical ventilation, changing breathing circuits of ventilator only if malfunction or visibly contaminated and using endo-tracheal tubes with dorsal lumen to allow respiratory secretions to drain. ***(Tablan, et al., ٢٠٠٤)*** Lately, health care infection control practices advisory committee suggested also implementing ventilator bundle which is a group of evidence-based practices that when implemented together for ventilated patients resulted in dramatic reductions in the incidence of VAP.

The ventilator bundle has four key components:

- Elevation of the head of the bed to between ٣٠ and ٤٥ degrees.
- Daily "sedation vacation" and daily assessment of readiness for extubation.
- Peptic ulcer disease prophylaxis (unless contraindicated).
- Deep venous thrombosis (DVT) prophylaxis (unless contraindicated). ***(Curley, et al., ٢٠٠٦)***

Aim Of The Work

The aim of this work is to study the prevalence and risk factors of VAP in ventilated patients admitted in PICU. We also aim to assess the impact of implementing head of bed elevation, sedation vacation, weaning and assessment of spontaneous breathing and peptic ulcer prophylaxis on VAP rates.

Overview On Mechanical Ventilation

What is meant by mechanical ventilation?

Assisted ventilation can be defined as the movement of gas into and out of the lung by an external source connected directly to the patient. The external source may be a resuscitation bag, a continuous distending pressure device, or a mechanical ventilator. Attachment to the patient can be via a face mask, endotracheal tube, nasal prongs, or tracheotomy. Although not in general use today in modern intensive care nurseries, negative-pressure ventilation can be applied by an apparatus surrounding the infant's thorax. ***(Goldsmith and Karotkim, ٢٠٠٣)***

Indication of mechanical ventilation

The principal indication for mechanical ventilation (MV) is respiratory failure. ***(Amitai, et al., ٢٠٠٤)*** It can be also indicated when other simple measures of respiratory support (oxygen, aerosol, chest physiotherapy and suctioning) are not effective to improve oxygenation and/ or ventilation. ***(Viana, et al., ٢٠٠٤)***

MV is indicated for both hypercapnic respiratory failure and hypoxemic respiratory failure. It is also indicated for intentional hyperventilation in the setting of major head injury with elevated intracranial pressure and for suspicion of clinical brain herniation from any cause. ***(Amitai, et al., ٢٠٠٤)***

Respiratory failure is almost always and most appropriately a clinical diagnosis. The decision to intubate and mechanically ventilate is generally made purely on clinical grounds without delay for laboratory evaluation or pulmonary function data. ***(Amitai, et al., ٢٠٠٤)*** **As shown in Table ١.**

Table (١): Laboratory and clinical criteria for mechanical ventilation

Persistent arterial hypoxemia
Arterial oxygen saturation below ٨٥٪ inspite of ٧٠ % oxygen therapy.
$PaO_٢$ below ٦٠ mmHg inspite of ٧٠ % oxygen therapy.
Cyanosis inspite of ١٠٠٪ oxygen therapy.
Alveolar hypoventilation
Altered consciousness or $PaCo_٢$ above ٦٠ mmHg (due to severe ventilation-perfusion mismatch or respiratory muscle fatigue).

(Slutsky, ٢٠٠٥)

Respiratory failure may be caused by disorders at any point in the respiratory system: respiratory center in the brain stem, spinal cord, motor nerve roots, respiratory muscles, the thoracic cage, airways and the lung interstitium and pulmonary vessels. ***(Henning and South, ١٩٩٩)*** As shown in **Table ٢**

Table (٢): Causes of Respiratory Failure:

Pulmonary causes:

- Respiratory distress syndrome.
- Aspiration syndromes.
- Pulmonary hemorrhage.
- Pneumonia.
- Pulmonary alveolar proteinosis.
- Wilson-Mikity syndrome.
- Bronho-pulmonary dysphasia.
- Pulmonary insufficiency of prematurity.
- Pneumothorax.
- Tumors.
- Diaphragmatic hernia.
- Cylothorax.
- Congenital malformations (Lobar emphysema, cystic adenomatoid malformation, lymphangiectasis).
- Cystic fibrosis.
- Vasculitis, collage vascular diseases.

Central causes:

- Status epilepticus.
- Severe static encephalopathy.

- Brain stem insult.
- Brain abscesses, hematoma and tumors.
- Apnea of prematurity.
- Drugs: morphine, Magnesium sulfate, Mepivcaine, meperidine).
- Arnold-Chiari malformation (Central type).
- Abnormalities of muscles of respiration.
- Phrenic nerve palsy.
- Spinal cord injury.
- Werdnig-Hoffmann syndrome.
- Myasthenia gravis.
- Myopathy.
- Neuropathy.
- Guillan-Barre syndrome.
- Botulism.

Airway obstruction.

- Laryngomalacia.
- Chonal atresia.
- Pierre Robin syndrome.
- Micrognathia.
- Nasopharyngeal tumor.
- Adenotonsillar hypertrophy.
- Retropharyngeal abscess.
- Subglottic stenosis.
- Acute epiglottitis
- Foreign body aspiration

Miscellaneous

- Congestive heart failure.
- Persistent fetal circulation.
- Post operative anesthesia, sedation.
- Extreme immaturity.
- Shock.
- Sepsis.
- Hypoglycemia.
- Electrolyte abnormalities.
- Acid-base imbalance (Sepsis, renal failure, diabetic ketoacidosis, hepatic disease)

(Baker and Ruddy, ٢٠٠٠ and Goldsmith and Karotkim, ٢٠٠٣)

To summarize, absolute indications of MV include apnea, persistent hypoxemia, severe hypoventilation and markedly elevated intracranial pressure while relative indications include shock state, deep coma and refractory status epilepticus. ***(Khilnani and Uttam, ٢٠٠٤)*** As shown in **Table ٣.**

Table (٣): Indications of Mechanical ventilation:

Resuscitation from circulatory arrest; shock
Hypoventilation and apnea;
Respiratory failure due to hypoxemic and intrinsic pulmonary disease,
Respiratory assistance for super normal gas exchange, including both persistent pulmonary hypertension (newborn or post-cardiac) and increased intracranial pressure;
Loss of mechanical integrity of the respiratory apparatus (e.g., muscle weakness, paralysis);
Prophylactic indication as post-surgical recovery and to reduce work of breathing.

Khilnani and Uttam, ٢٠٠٤

Means and Modes of Mechanical Ventilation:

Ventilators can be classified according to the manner in which they control ventilation, often termed the ventilator mode. To start inspiration, the machine can be triggered by the patient (Assistor type), by ventilator only (controller type), or by both the patient and the ventilator (assistant-controller type). In assistor-controller ventilator, a device allows the patient to initiate some respirations; however, it also has a pre-determined frequency of intermittent mandatory ventilation (IMV) that can be used as backup. ***(Goldsmith and Kartkim, ٢٠٠٣)***

Continuous mandatory ventilation (CMV)

Breaths are delivered at preset intervals, regardless of patient effort. This mode is used most often in the paralyzed or apneic patient because it can increase the work of breathing if respiratory effort is present. Many ventilators do not have a true CMV mode and offer A/C instead. ***(Amitai, ٢٠٠٦)***

Intermittent mandatory ventilation (IMV)

With IMV, breaths are delivered at preset interval, and spontaneous breathing is allowed between ventilator-administered breaths. Spontaneous breathing occurs against the resistance of the airway tubing and ventilator valves which may be formidable. This mode has given way to synchronous intermittent mandatory ventilation (SIMV). ***(Amitia, ٢٠٠٦)***

Assist-control (A/C)

The ventilator delivers preset breaths in coordination with the respiratory effort of the patient. With each inspiratory effort, the ventilator delivers a full assisted tidal volume. Spontaneous breathing independent of the ventilator between A/C breaths is not allowed. As might be expected, this mode is better tolerated than CMV in patients with intact respiratory effort. ***(Amitai, ٢٠٠٦)***

If the patient does not trigger the ventilator frequently enough, the ventilator initiates breaths, ensuring the desired minimum respiratory rate. ***(Porter and Kaplan, ٢٠٠٧)*** A high sensitivity (shallow inspiratory effort) may cause unintentional triggering of mandatory breaths**,** and a low sensitivity may increase work of breathing needed to open a demand valve to increase gas flow to the patient. ***(Rotta, ٢٠٠٦)***

Synchronized intermittent mandatory ventilation (SIMV)

SIMV delivers breaths at a set rate and volume that is synchronized to the patient efforts. In contrast to A/C, patient efforts beyond the set respiratory rate are unassisted, although the intake valve opens to allow a breath. This mode remains popular, despite the fact that it neither provides full ventilator support as does A/C nor is an effective means of liberating the patient from mechanical ventilation. ***(Porter and Kaplan, ٢٠٠٧)***

Synchronization attempts to limit barotraumas that may occur with IMV when a preset breath is delivered to a patient who is already maximally inhaled (breath staking) or is forcefully exhaling. ***(Amitai, ٢٠٠٦)***

CPAP and PEEP (Continuous positive airway pressure and positive end expiratory pressure)

CPAP refers to the maintenance of positive pressure throughout the ventilatory cycle. It implies that ventilation is occurring spontaneously without mechanical pressure breath, it is referred to as PEEP. ***(Khilnani and Uttam, ٢٠٠٤)***

It is a mode of operation (debated as to whether truly a mode, because no tidal volume is generated by the ventilator) in which a preset pressure is maintained while the patient is allowed to breathe spontaneously. Patient determines his or her own rate and tidal volume. It increases mean airway pressure and; therefore oxygenation. Possibly decreases work of breathing if optimizes functional residual capacity (FRC) and ventilation/perfusion matching. ***(Goldsmith and Karotkim, ٢٠٠٣)***

In the pediatric patient, it is used most commonly in the weaning of the chronically ventilated patient with chronic lung disease, or in patients in whom malacia of the airway is the predominant factor. In a neonate CPAP is commonly used as a mode of assisting the respiratory status for lung disease to avoid mechanical ventilation, as well as a weaning mode. ***(Khilnani and Uttam, ٢٠٠٤)***