

## Review Article

# Pediatric Ventilator Bundle

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## Abstract

The bundle approach to providing medical care has become increasingly popular in last 25 years. A care bundle is a group of interventions which when delivered together lead to a better outcome than performing interventions individually, representing an improvement over a non-structured approach. Nowadays care bundle is also seen as a valuable tool for audit and quality assurance. As such, it has become popular both as a management and clinical tool.

Patients with mechanically-assisted ventilation have a high risk of developing healthcare-associated pneumonia. The Ventilator Bundle introduced by Patient Safety First, a national campaign launched in June 2008. In this article will be examined Pediatric ventilator bundle and research result related this.

## ABBREVIATIONS

PICU: Pediatric Intensive Care Unit; NICU: Neonatal Intensive Care Unit; VAP: Ventilator Associated Pneumonia

## INTRODUCTION

Ventilator associated pneumonia (VAP) is defined as pneumonia occurring more than 2 calendar days following endotracheal intubation [1,2]. VAP is one of the most common healthcare associated infections for critical care patients [3-5]. It is stated that the VAP incidence varies according to type of intensive care unit (ICU), institution and country [5,6]. Centers for Disease Control and Prevention – CDC indicated that VAP rates vary between 0.2 to 0.8/10<sup>3</sup> ventilator days in 2012 in pediatric intensive care units [7]. According to the data from Turkish Ministry of Health, VAP rates vary between 5.3 to 9.5/10<sup>3</sup> in 2011, 3.3 to 8.7/10<sup>3</sup> in 2012, 6.0 to 7./10<sup>3</sup> in 2013, 4.7 to 8.5/10<sup>3</sup> in 2014, 3.0 to 8.2/10<sup>3</sup> in 2015 and 1.5 to 11.6/10<sup>3</sup> in 2016 in pediatric intensive care units (Table 1) [8-13].

Although there are a great number of evidence based guidelines for VAP prevention, literature stated that nearly 50% of the patients received the medical care recommended in line with current scientific evidence. Therefore the care bundle approach is emerged by the Health Care Improvement Institute with the purpose of achieving the desired results in health care and increasing conformity to procedures which should always be carried out in the same way [3-6,14-18].

## Care bundle

Care bundle is defined as implementation of a small set of evidence based interventions together for a defined patient population that when each one of all executed individually, improve patients recovery process and outcomes; when executed all together providing better outcomes than implemented individually. It is recommended that care bundles should consist three to five evidence based interventions which cannot be

implemented in practice each time in a stable and consistent way [5,18-20]. The first two care bundle approaches developed by the Institute for Healthcare Improvement were applications on ventilator associated pneumonia and central line associated bloodstream infections [20].

## Ventilator bundle

VAP is associated with increased morbidity, mortality, antibiotic administration, duration of mechanical ventilation, length of PICU and NICU stay and hospital cost among vulnerable pediatric patients. Therefore VAP is considered as a critical threat to patient safety. For this reason, ventilator bundle is regarded as an important component of patient safety in critical pediatric patient care [1,2,4,6,14,18].

Ventilator bundle developed for adult patients by the Institute for Healthcare Improvement consists five interventions:

1. Head of bed elevation to between 30-45°,
2. Daily sedative interruption and daily assessment of readiness to extubate,
3. Peptic ulcer prophylaxis,
4. Deep vein thrombosis prophylaxis
5. Daily oral care with chlorhexidine [18,20].

Pediatric ventilator bundle differs from adult ventilator bundle. Pediatric ventilator bundle consists of four interventions:

1. Head of bed elevation to between 15-30° for neonates, 30-45° for infants or above
2. Daily assessment of readiness to extubate (daily sedative interruption is not recommended in pediatrics due to high risk of unplanned extubation)
3. Peptic ulcer prophylaxis (as appropriate for the age and condition of the child)

**Table 1:** Pediatric Ventilator Bundle Studies.

Authors and study years	Setting, number of patients	Head of bed elevation	Daily assessment of readiness to extubate	Peptic ulcer prophylaxis	Oral Care	Other	VAP rates in pre-implementation period	VAP rates in post-implementation period
Brilli et al. 2008[22]	PICU, n:26	+	+	+	Daily oral care with chlorhexidine		7.8/10 <sup>3</sup>	0.5/10 <sup>3</sup>
Gurskis et al. 2009[23]	PICU, n:755	+			Regular oral care with chlorhexidine	Handling of ventilator circuits and oral suctioning, hand hygiene	5.6/10 <sup>3</sup>	1.9/10 <sup>3</sup>
Bigham et al. 2009[24]	PICU, n:1782	+			+	Hand hygiene, ventilator circuit care, oral suction device stored in unsealed plastic bag, in-line suction catheter changed when soiled, condensate drained every 2 to 4 hours and when turning	5.6/10 <sup>3</sup>	0.3/10 <sup>3</sup>
Brierley et al. 2012[31]	PICU, n:730	+		+	+	Clean suctioning, documentation to be completed 4 hourly, compliance monitoring	5.6/10 <sup>3</sup>	0.0/10 <sup>3</sup>
Rosenthal et al. 2012[25]	PICU, n:4339	+	+	+	+	Active surveillance, hand hygiene, minimizing the duration of ventilation, orotracheal intubation, cuff pressure management, care of ventilator circuits, avoidance of gastric distention, use of sterile water to rinse respiratory equipment	11.7/10 <sup>3</sup>	8.1/10 <sup>3</sup>
Rosenthal et al. 2012[26]	NICU, n:6829	+	+	+	+	Active surveillance, hand hygiene, minimizing the duration of ventilation, orotracheal intubation, cuff pressure management, care of ventilator circuits, avoidance of gastric distention, use of sterile water to rinse respiratory equipment	17.8/10 <sup>3</sup>	12.0/10 <sup>3</sup>
Muszynski et al. 2013[27]	PICU, n:725	+	+		+	Hand hygiene, suctioning oral secretions, use closed suctioning systems	3.9/10 <sup>3</sup>	1.8/10 <sup>3</sup>
Ceballos et al. 2013[28]	NICU, n:	+	+		+	Minimize exposure to pathogens, intubation and equipment management	71% reduction	
Obeid et al. 2014[29]	PICU, n:107	+	+	+	+	Hand hygiene, close aspiration system, orogastric tube for residual volumes before feeding,	%52	%6
Azab et al. 2015[30]	NICU, n:143	+	+		Proper timed mouth care with normal saline and suction of oropharyngeal secretion.	Hand hygiene, sterile suction and handling of respiratory equipment. Intubation, re-intubation and endotracheal tube (ETT) suction as strictly indicated by unit protocol (document). Change ventilator circuit if visibly soiled or mechanically malfunctioning (document)	36.4/10 <sup>3</sup>	23.0/10 <sup>3</sup>
De Cristofano et al. 2016[32]	PICU	+			Oral care with chlorhexidine	A clean and dry ventilator circuit, and daily interruption of sedation.	6.3/ 10 <sup>3</sup>	0.0/10 <sup>3</sup>

4. Deep vein thrombosis prophylaxis (unless contraindicated; as appropriate for the age and condition of the child) [21].

Besides these interventions, there are additional care aspects that should be considered. These aspects are related with oral care, ventilator circuit care and aspiration devices [21].

**Oral care:** Daily comprehensive oral care should be provided according to age and clinical condition of the patient. The frequency of the oral care should be increased for high risk patients. The oral care products including chlorhexidine should be used for children older than 2 months of age [21].

**Ventilator circuit care:** Heated ventilator circuits should be used to decrease the occurrence of condensate. The water accumulated in a ventilator circuit should be drained away every 2-4 hours and prior to every position change. The ventilator circuits should be changed when it is a visibly soiled or mechanically malfunctioning. Before and after contact with ventilator circuits hand hygiene have to be provided [21].

**Aspiration devices:** Oral aspiration device should be kept in a clean non-sealed plastic bag when not in use. Open aspiration catheter should not be reused. In-line aspiration catheter systems should be changed soiled or otherwise indicated [21].

## Pediatric ventilator bundle studies

Many researchers have created their own customized pediatric ventilator bundle. Nevertheless it can be seen from researches that researchers did not prefer to use deep vein thrombosis prophylaxis intervention for pediatric ventilator bundles. Recent studies have reported reduction of VAP rates by implementing pediatric ventilator bundle [22-32]. In addition some researchers reported that ventilator bundle implementation decreased the length of PICU stay, decreased the duration of mechanical ventilatory therapy, decreased the mortality rates and was cost saving [22,28-30]. The pediatric ventilator bundle studies are summarized in Table (2).

Brilli et al. (2008), implemented ventilator bundle consisted of head of bed elevation, daily sedation vacations and assessment of readiness to extubate, peptic ulcer disease prophylaxis and daily oral care with chlorhexidine resulting in reduction in both VAP rates (from 7.8 to 0.5/10<sup>3</sup> ventilator days), length of hospital stay and cost saving of approximately \$ 2.4 million [22].

Gurskis et al. (2009), stated that implementation of multimodal implementation (education of staff and evidence based infection control measure including handling of ventilator circuits and oral suctioning, hand hygiene, regular oral care with chlorhexidine, and backrest elevation) decreased the VAP rates from 5.6/10<sup>3</sup> to 1.9/10<sup>3</sup> ventilator days in PICU [23].

Bigham et al. (2009), found significantly lower VAP rates after implementing ventilator bundle compared with pre-implementation and implementation periods of ventilator bundle in PICU [24].

Rosenthal et al. (2012), carried out a before-after study to determine the VAP rates after ventilator bundle implementation in 8 PICUs in 5 developing countries including Colombia, El Salvador, India, the Philippines, and Turkey. They stated that

ventilator bundle implementation was associated with reduction in the VAP rates from 11.7/10<sup>3</sup> to 8.1/10<sup>3</sup> ventilator days [25]. Rosenthal et al. (2012), carried out a similar study in NICUs of 10 developing countries: Argentina, Colombia, El Salvador, India, Mexico, Morocco, Peru, Philippines, Tunisia, and Turkey. They demonstrated that they decreased the VAP rates from 17.8/10<sup>3</sup> to 12.0/10<sup>3</sup> ventilator days by implementation of ventilator bundle [26].

Muszynski et al. (2013), reported that implementation of pediatric ventilator bundle reduced the ventilator-associated tracheobronchitis rate from 3.9/10<sup>3</sup> to 1.8/10<sup>3</sup> ventilator days [27]. Ceballos et al. (2013), achieved 71% reduction in VAP rates, 31% reduction in ventilator days, 72 fewer hospital days, resulting in estimated cost saving \$ 300,000 [28].

Obeid et al. (2014), stated that implementation of pediatric ventilator bundle significantly reduced the VAP rate, duration of mechanical ventilation therapy and length of hospital stay with potential decrease in cost [29]. Similarly Azab et al. (2015), reported that implementation of ventilator bundle reduced VAP rates and length of NICU stay [30].

In addition, some researchers have reported that they eliminated VAP using care bundles [31,32]. Brierley et al. (2012), demonstrated that they decreased the VAP rates from 5, 6-0 per 10<sup>3</sup> ventilator-days in the PICU by implementing ventilator bundle by a nurse-led VAP surveillance programme [31]. Similarly De Cristofano et al. (2016), demonstrated that they eliminated VAP by implementation over 2 years of a ventilator bundle in PICU [32].

Care bundles are not 'set in stone'. Indeed, it is part of the underlying philosophy that the existence of a care bundle should in itself encourage review of the evidence, together with the incorporation of new evidence and appropriate modification of clinical care guidelines. This process encompasses staff education in best practice [33].

Current studies have demonstrated that ventilator bundle implementation was associated with significant reduction in VAP rates, duration of mechanical ventilation, antibiotic administration, length of PICU and NICU stay and hospital costs. In conclusion, implementation pediatric ventilator bundle seems to be an effective approach achieving better patient and clinic outcomes with evidence based safe and multidisciplinary approach.

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