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Bundle Method in Reducing Pneumonia Associated with Mechanical Ventilation in Newborns and Children: Integrative Review

REVIEW

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Abstract

Infections related to health care are a public health problem, given the repercussions of the event to the morbidity and mortality of the population and having health spending. Pneumonia Associated to Mechanical Ventilation has the incidence of 8.1% to 57.1% in neonates and 23% in children. This study is an integrative literature review aimed to check the scientific production concerning the use of bundle guidelines to reduce of PAV in children and newborns in intensive care units and analyze the results of these research. For data collection, the keyword bundle, and the descriptors infant, newborn; Intensive Care Units, Neonatal Pneumonia, Ventilator-Associated and Child(ren) for online search in databases: PUBMED, SCOPUS, LILACS and CINHAL. The initial result of the search was 891 articles and after application of inclusion and exclusion criteria, the sample resulted in nine articles. This study points out that in general VAP prevention measures found in bundles were effective in reducing PAV rates in neonates and pediatric patients. However, there are still differences in the development of some interventions, especially for newborns. It is necessary to develop other studies, including the better level of evidence to address the use of bundle for PAV prevention of these population, considered more vulnerable to incidents related to health care.

Keywords
Ventilation Associated with Pneumoni; Newborn; Patient Safety; Bundle; Child.

Introduction

Infections associated with Healthcare (IRAS) is currently a public health problem, given the repercussions of the event to the morbidity and mortality of the population and the health expenditures [1]. This

problem is likely to occur in different population groups, which are directly related to intrinsic and welfare risk factors [2].

As an example of this problem, the Pneumonia Associated to Mechanical Ventilation (PAV) shows up as the second most common nosocomial infection in neonatal intensive care units [1], with an incidence of 8.1% to 57.1%. In neonates, it can be associated with the following risk factors: endotracheal reintubation, enteral nutrition, low birth weight and prematurity. In pediatric patients, it can be associated with endotracheal reintubation, use of the immunosuppressant drug and previous use of antibiotics [3-4]. The most common microorganisms isolated in PAV in neonatal units are *Pseudomonas aeruginosin; Staphylococcus aureus, Klebsiella pneumonia and Escherichia coli* [5].

Regarding this problem, it is essential that health services adopt preventive strategies to minimize the risk of PAV in neonates and pediatric patients through protocols and practices based on evidence that promotes the reduction in infection rates. Among the possible interventions, there is the bundle as a tool for patient safety, which has been the subject of research in other studies [6].

The bundle is a set of measures that when implemented together, it can get better results than when implemented individually. Interventions are based on good practices including constant surveillance, health staff training and adoption of strategies to prevent infections. Therefore, it is necessary to have high adherence by professionals to provide satisfactory results in the infection control [5].

Studies show the effectiveness of PAV prevention bundle, recommended by the Disease Control and Prevention Center (CDC] for adult patients. However, these recommendations should be evaluated for pediatric patients and neonates, because they have different characteristics needing appropriateness of interventions to understand their specificities.

Thus, this review highlights the following study guiding question: What guidelines have been used as bundle component aimed at reducing pneumonia associated with mechanical ventilation in children and newborns in intensive care units?

Thus, the study aims to determine the scientific productions for the use of bundle guidelines to reduce pneumonia associated with mechanical ventilation in children and newborns in intensive care units and analyze the results of the research produced.

Methodology

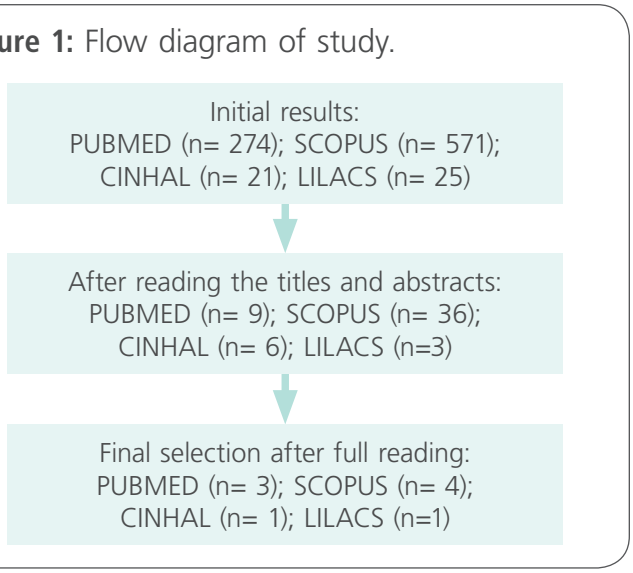
This is an integrative review, based on the synthesis and comparative analysis of the results of previous studies. Its development was followed by five steps: (1) preparation of an integrative review protocol having the subject, research question, strategy for databases, descriptors, crossings, inclusion and exclusion criteria; (2) data collection to include publications that contribute and relevant answers to the research question; (3) extracting the relevant information contained in the studies (4) data analysis and interpretation; (5) presentation of the review [7].

There were the scientific publications indexed in databases collected to study: PUBMED, SCOPUS, LILACS and CINHAL without restriction for the year of publication. Data collection was conducted in March 2016. The following descriptors were used identified in Descriptors of Health Sciences (DECs)/Medical Subject Headings (MESH): 1#Recém-Nascido/Infant, Newborn; 2#Unidades de Terapia Intensiva Neonatal/Intensive Care Units, Neonatal; 3#Pneumonia Associada à Ventilação Mecânica/Pneumonia Associated with Mechanical Ventilator-; 4#Criança/Child(ren), 5# Unidades de Terapia Intensiva Pediátrica/ Pediatric intensive care and # 6 bundle as keyword. The crossing used in uncontrolled search were: (3# AND #6 AND 1#); (3# AND #6 AND 2#); (3# AND #6 AND 4#); (3# AND #6 AND 5#).

Inclusion criteria were: full articles available on databases without restriction languages that addressed

the interventions through the bundles guidelines. Publications on literature review format, editorials, letters, opinion articles, duplicate articles, theses, dissertations or that did not cover the subject of research were excluded. The selection of publications started after reading the titles and abstracts. The studies no available in full and duplicate that had incomplete or insufficient data to answer the research question were later removed, according to the flowchart below: **(Figure 1)**

Figure 1: Flow diagram of study.



Results and Discussion

There were 837 articles found initially, and after reading the titles and abstracts and reading in full, there were nine articles. **Table 1** is a summary of the studies identified and included in the integrative review according to the guidelines adopted in the bundle method for the prevention of PAV and the main results.

It was observed that four articles (44.5%) were investigated in developed countries, and the rest (55.5%) were carried out in developing countries in South America, Africa, and Asia. Regarding the population, there was a slight predominance in the neonatal, five articles (55.5%) compared to the pediatric age group (44.5%). The most developed type of study was the prospective, almost experimental,

Table 1. Interventions identified as elements of the bundles and citation frequency Natal, RN, 2016.

Interventions identified as bundles elements	Frequency (n=8)	
	Absolute (f)	Relative (%)
Hand washing	8	88.8
Hygiene frequent oral cavity	7	77.7
Maintenance of the headboard elevation	7	77.7
Ventilator circuit maintenance without condensation	6	66.6
Tracheal aspiration aseptically	5	55.5
Ventilator circuit exchange only in case of visible of dirt or malfunction	5	55.5
Education activities for multidisciplinary team	4	44.4
Daily evaluation of the need for invasive mechanical ventilation	3	33.3
Cuff pressure maintenance in the tracheal tube ≥ 20 mm H2O	2	22.2
Preference for intubation	1	11.1
Check the positioning of the endotracheal tube periodically	1	11.1
Daily evaluation for the need of sedation	1	11.1
Daily evaluation for the need of using antibiotics	1	11.1
Prevention of gastric ulcer using antagonists drugs Histamine H2 receptor for fasted patients	1	11.1
Frequent tooth brushing	1	11.1
Prior aspiration of oropharyngeal before tracheal aspiration	1	11.1

Source: Data for the nine articles that were included in the integrative review carried out by the authors.

with (66.7%), followed by two transversal almost experimental studies (22.2%) and a retrospective case-control (11%). The year with most publication was 2013 (33.3%).

The initial objective of all studies was to analyze the implementation of the bundle to prevent PAV and the impact when reducing PAV rates. Concerning the type of bundle methodology, there were at least three interventions and a last nine interven-

Table 2. Description of articles identified on research databases on a bundle for preventing pneumonia associated with mechanical ventilation and results summary. Natal, 2016.

Authors	Country/ Year of Publication	Objective/Methodology	Interventions	Conclusions
Thibeau S, Boudreaux C [8]	The United States, 2013	To explore the use of breast milk (colostrum, transitional milk, and mature milk) in oral hygiene as part of the bundle to prevent PAV in premature infants weighing ≤1500g in mechanical ventilation/Descriptive, retrospective, case-control, almost experimental study	Hand hygiene of professionals; aspiration of the oral cavity periodically; use of two sterile swabs to the friction of the mouth and lips with breast milk; every 4 hours a day until the end of the mechanical ventilation	There was a slight reduction of PAV compared to the control group using sterile distilled water for oral hygiene. However, there was no statistical significance. There were no adverse event reports related to the use of breast milk. Experimental studies of randomized clinical trial type are recommended to control the variables
QiZhou, et al [9].	China, 2013	To evaluate the effectiveness of an infection control program in reducing PAV in a neonatal intensive care unit (NICU) in China/Prospective, descriptive, and almost-experimental study	Conducting educational activities of hands hygiene of professionals and PAV prevention measures every four months; weekly exchange ventilation circuit and maintenance of the ventilation circuit without condensation; daily evaluation of the need for ventilation; tracheal aspiration closed system; periodic evaluation of the need to use antibiotics	PAV rate decreased from 48.84 per 1,000 ventilator days to 18.50 per 1,000 ventilator days; The overall mortality rate of hospitalized newborns significantly decreased from 14% to 2.7%. There is a possibility to implement interventions in developing countries. Hawthorne bias in the results
Azab SFA,et al. [10].	Egypt, 2015	To evaluate the effectiveness of the bundle to prevent PAV and reducing the PAV rates in neonates/prospective observational, descriptive, almost-experimental study	Maintenance of the high head between 30° and 45°; hand hygiene of professionals; Aseptic tracheal aspiration technique; intubation, reintubation and endotracheal aspiration indication as protocol; exchange ventilation circuit only with apparent dirt or malfunction; maintaining the ventilation circuit without condensation; oropharyngeal aspiration frequently and oral hygiene with 0.9% saline at intervals; daily evaluation for extubation; and daily suspension of sedation	PAV rate was significantly reduced by 67.8%, corresponding to 36.4 PAV episodes/1000 days on mechanical ventilation to 38.2% corresponding to 23 episodes of PAV ventilation days /1.000 (0.565 RR 95% range confidence from 0.408 to 0.782, p = 0.0006). Reduction of total neonatal mortality did not reach statistical significance (25% versus 17.3%, P = 0.215).
Rosenthal VD, et al. [11].	Argentina, 2012.	To evaluate the bundle of PAV prevention in pediatric ICU in five developing countries/prospective, multicenter, almost-experimental study	Hand hygiene of professionals; maintaining the head elevated from 30° to 45°; daily evaluation for the need for ventilation; oral hygiene with antiseptic; preference for endotracheal intubation; cuff pressure maintaining the endotracheal tube above 20mmH2O; circuit exchange with visible dirt or malfunction; avoid gastric distension	Reduction of PAV by 31%. Applicable strategy in developing countries.

Authors	Country/ Year of Publication	Objective/Methodology	Interventions	Conclusions
Perugini MR, et al. [12].	Brazil, 2015	To analyze the bundle of PAV control in Pediatric Intensive Care Unit, the education activities and PAV rates of the University Hospital of Londrina-PR./ transversal and descriptive study	Hand washing, maintaining elevation of the head between 30° and 45°; gavage maintenance orally; oral hygiene, three times a day; Circuit exchange only in case of visible dirt or malfunction; maintaining the ventilation circuit without condensation; maintaining the inflation of the endotracheal tube cuff above 20mmH2O; periodic training of the multidisciplinary team	Reduction of PAV in 64.8%.
Ceballos K, et al. [13]	The United States, 2013	To evaluate bundle in PAV prevention in neonatal ICU of a university hospital/ prospective, almost-experimental study	Hand washing OF professionals; maintenance of elevation of the head between 15° to 30°; oral hygiene preferably colostrum, or in the absence sterile water, every 4 hours; Aspiration frequent oral cavity; Prior aspiration of oropharyngeal before tracheal aspiration; check the positioning of the endotracheal tube every 4 hours; daily evaluation for extubation; exchange circuit is new intubation. Staff training	Reduction of VAP rate IN 71%; 31% reduction in staying days in mechanical ventilation and saving $ 300,000 in hospital costs
Brierley J, et al. [14].	The United Kingdom, 2012	Evaluating the reduction of PAV in pediatric patients after implementation of the bundle prevention of PAV/prospective, descriptive, almost-experimental study	Maintenance of high head between 20-30°; Oral hygiene with chlorhexidine 4/4 hours and toothbrushing 12/12 hours; tracheal aspiration aseptically; gastric ulcer prevention with the use antagonists Histamine H2 receptor for fasting patients	Reduction of PAV for 12 months
Bigham MT, et al. [15].	The United States, 2009	To characterize the PAV in a pediatric ICU; Implement a PAV prevention bundle evidence-based pediatric; Analyze reducing rates of PAV/prospective, descriptive, almost-experimental study	Hand washing professionals; maintaining the ventilation circuit without condensation; Circuit exchange only in case of visible dirt; maintaining the elevation of the head between 30° and 45°.	Reduction of PAV in 5.6/1000 ventilator days to 0.3/1000 ventilator days.
José JD, et al. [16]	Brazil, 2015	To analyze the PAV rate in neonates of a NICU after bundle implementation of infection prevention and actions of education and VAP rates of the University Hospital of Londrina-PR./ almost-experimental, cross-sectional descriptive study	Hand washing of professionals; maintaining the ventilation circuit without condensation; Circuit exchange only in case of visible dirt; the head elevation of maintenance at 30°; aspiration of the upper airways often; use of the closed endotracheal suction system, oral hygiene	PAV rate decreases by 68.5%.

Source: Data for the nine articles that were included in the integrative review carried out by the authors

tions. The results show a PAV reduction varying between 31% and 71% after bundles implementation.

Using the Oxford Center for Evidence-based Medicine1 as a reference [17], according to the classification of studies by levels of scientific evidence, the results showed eight studies in the level of evidence type 2C (88.8%), since they were studies of the type observing results (outcomes research) and one study (22.2%) was case-control type, therefore classified as 3B level.

Table 2 shows the interventions described as elements of the bundles and the number of times that each strategy was cited in the nine studies.

The practice of hand hygiene by the health professionals was described in most studies [8-13,15]. It is the most important and recognized measure for prevention and control of infections related to care. However, consolidate it as a routine practice of health professionals is a daily challenge [18]. A study in a NICU showed a reduction by 38% of PAV rate in neonates of very low-weight after the implementation of a strategy of practical improvement of hand hygiene, proposed by the Vermont Oxford Institute [20].

Regarding the continuing education of health professionals, only three studies used this strategy [9, 12, 13]. It is an instrument contributing to the transformation of care practice, although it is one of the main procedures to adopt safe practices in health care. Therefore, adherence to bundles advocated intervention becomes essential, given that many studies have shown a reduction in IRAS rates by educating health professionals [21, 22].

About the regular hygiene of the oral cavity, the results of the studies are conflicting. The IHI recommends an additional way to VAP prevention bundle in pediatric patients, with the adequacy of treatments respecting the specificities of each age of the patient [23]. For example, the use of chlorhexidine is not recommended for infants below two months. This generates a variety of interventions for oral hygiene in infants. In studies of the review, there was the use of saline 0.9%, sterile distilled water and breast milk [8, 10, 13].

It is known about the existence of the protective factor of breast milk in reducing infections and their safety using with newborns at high risk. However, there is no evidence available that address specifically its use in oral hygiene. Thus, this statement requires studies with more rigorous design as randomized controlled trials. Corroborating the findings, another study highlighted that the efficacy of oral cleaning with chlorhexidine in children admitted to the ICU is considered a moderate evidence when related to the reduction in the occurrence of PAV. Brushing teeth is considered a weak evidence [24-26].

The intervention of the headboard elevation was present in most of the bundles [10-15], which is considered a weak evidence [25]. According to the CDC´s recommendation, there are differences in the angle of inclination for newborns and pediatric patients [27]. The newborns should remain with head between 10° to 30° degrees, unlike pediatric patients with angles between 30° and 45°. The results of this review showed that only one study with newborns followed the recommendation [13], while in a study of pediatric patients the angle used was 20°-30° [14].

Most of the interventions related to the care of the ventilation circuits and system maintenance without water condensation and exchange only in case of visible dirt or malfunction [9-13, 15], followed the recommendations of IHI [23]. However, there are differences in the level of evidence of these strategies when applied in neonates because the evidence is considered weak. In pediatric patients, only the circuit exchange intervention was considered a moderate evidence [25].

Among the actions related to the endotracheal tube, there are preference for endotracheal intubation, tube placement periodically checking and maintenance cuff overpressure of 20 mm H_2O for pediatric patients [11-13]. These interventions are

part of the IHI recommendations, except for the periodic checking of the positioning of the endotracheal tube [23]. However, the use of endotracheal tubes with cuff does not apply to newborns.

Among the interventions for maintenance of permeable airways, tracheal aspiration aseptically was identified with system closed and hands off use [9, 10, 13, 14, 16]. The use of the closed suction system has had low evidence in reducing PAV over the other technique of vacuum, with the system off [4, 30]. The preference for periodic aspiration of the upper airways over the lower airways [8.10, 13.16] was justified by the fact that the accumulation of secretions in the oropharynx favors the colonization of microorganisms and the occurrence of microaspirations. Endotracheal aspiration should be performed judiciously since it favors increased intracranial of the pressure in premature neonates and promotes the occurrence of intracranial hemorrhage [3].

The daily evaluation of the need for invasive mechanical ventilation is a moderate evidence in some studies of the review [9, 10, 13, 25]. Regarding the judgment of the need for sedation, it is preferably applied in pediatric patients, as the sedation of the newborn in the NICU is avoided. Previous use of antibiotics to treat other comorbidities is a risk factor for the development of PAV [3]. However, it was an intervention identified in only one study.

Regarding the use of H2 -receptor antagonists of histamine drugs and antacids for the prevention of gastric ulcer in newborns and pediatric patients, there is no recommendation for their use in preventing PAV [23, 28-30]. This intervention was only identified in only a study of this review [14].

Conclusion

The PAV prevention measures found in bundles, generally, were effective in the reduction of PAV rates in neonates and pediatric patients. However, there are still differences in the development of some interventions, especially for newborns. Among them, there is the practice of cleaning the oral cavity with colostrum, maintaining the elevation of the head between 15° to 30° and periodic circuit exchange.

The bundle objective is not to be a comprehensive reference to the therapy in the literature but a few set of interventions based on evidence carried out jointly by professionals from a health institution. The choice of interventions should consider the cost, ease of implementation and its adherence by the professionals in their care practices.

The results of this review showed that the interventions in the bundles can be applied in different situations, from developing to developed countries. However, the number of articles found on the topic in the investigated databases indicates the need to develop other studies, including the better level of evidence to address the use of the bundle in neonates and pediatric to prevent PAV for this population, considered most vulnerable to incidents related to health care.

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