Original Article

Assessing the Efficacy of Ventilator-Associated Event Prevention Bundle in the Intensive Care Units: An Intervention Study

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Abstract

Background: The use of evidence-based information as a prevention package and the quality of nursing care are effective in reducing infection rates to prevent ventilator-associated event (VAE) infections.
Aim: This study aims to evaluate the efficacy of ventilator-associated event (VAE) prevention bundle practices in the intensive care unit (ICU).
Methodology: This interventional study was conducted between January 1 and March 31, 2019. Data were collected using the Introductory Characteristics Form Regarding the Nurse Group, Training Evaluation Form for Ventilator-Associated Event Prevention Bundle Practice, and Follow-up Form for Ventilator-Associated Event Prevention Bundle. Prior to study, ethics committee approval and nurses' consent was obtained. The study was carried out with the intensive care unit nurses, and the period of the study included a total of 354 ventilator-days, 38 patients. Number, Percentage and Wilcoxon Test were used in the study.
Results: Bundle general compliance in the intensive care unit reached a compliance percentage of 85%. In the study, it was observed that the rates of infection reduced in pre-, during, and post-intervention periods. Besides, the fact that the number of patients increased but ventilator days decreased within post-intervention period was remarkable.
Conclusion: As a result, VAE prevention bundle practices, prepared in light of evidence-based guidelines, were found to reduce the rates of infection. The use of bundle practices in the intensive care units is recommended.

Keywords: Bundle, ventilator, ventilator bundle, VAE

Introduction

Healthcare-associated infections (HAI) are infections that first appear 48 hours or more after hospital admission (Kallet, 2019; Meagher et al., 2019). In hospitals, especially intensive care units (ICU), procedures applied to patients whose general medical condition worsens, as well as patients' view of routine follow-up, brings about invasive device-related infections (Harris et al., 2018). Pneumonia comes first among these infections and 83% of the recorded pneumonia are due to ventilator-associated event (VAE) (Younan et al., 2019). It is a known fact that VAE infections cause an increase in criteria like antibiotic resistance, length of stay, cost, mortality and morbidity. Prevention of VAE infections is of great importance for both preventing negative outcomes experienced by patients and reducing the burden of healthcare institutions (Sousa, Ferrito and Paiva, 2019).

After the Centers for Disease Control and Prevention (CDC) announced the new diagnostic criteria in 2013, Ventilator-Associated Pneumonia (VAP) has been started to be recorded as VAE (Hebert et al., 2018; Klompas, 2019). In Turkey, on the other hand, new diagnostic criteria have been started to be used along with the guideline published by the General Directorate of Public Health Ministry of Health in 2017 (T. C. Ministry of Health, General Directorate of Public Health. National Healthcare Related Infections Surveillance Guide, 2017). The new diagnostic criteria of VAE eliminates the complexity and subjectivity in pneumonia cases. This guideline suggested that some preventable complications of mechanical ventilation would require a different management approach, such as separating from infection diagnoses instead of making a diagnosis of infection only (Ziegler, 2019). The new diagnostic criteria separate the patient's general condition disorder from infection (Klompas, 2019).

In hospitals, especially in ICUs, infection control comes first among evidence-based and safe healthcare delivery. Infection control is not a single practical, instead, it is possible with bundle practices, collectively implementation of a set of evidence-based parameters (Sousa, Ferrito and Paiva, 2019). Bundle practices implemented with the nurse team in ICUs are crucial in reducing infection rates and providing safe evidence-based care. In an international, multicenter VAE bundle study in which nurses participated, it was concluded that with the application of bundle parameters, infection related ventilator-associated complications remit (Rello et al., 2019). In another study conducted for three years, infection control measures were applied together and a significant reduction was observed in the rate of Ventilator-Associated Condition (VAC) and Possible Ventilator Associated Pneumonia (PVAP) (Kubbara et al., 2019). The most important feature of this study is to contribute to the literature by observing the contributions of bundle practices for VAE infections. In this study, the impact of the combination of a VAE bundle with nursing care on infection rates was observed. The role of nurses in preventing VAE forms the outline of this study.

The hypotheses of this research are: $H_{0\text{-}1}$: The education given about the prevention and control of healthcare-associated infections has no effect on the knowledge level of the nurse group.

$H_{1\text{-}1}$: The education given about the prevention and control of healthcare-associated infections has an impact on the knowledge level of the nurse group.

$H_{0\text{-}2}$: Bundle operation has no effect in preventing ventilator-related incident infections in the Anesthesia and Reanimation-II Intensive Care Unit.

$H_{1\text{-}2}$: Bundle operation has an effect on preventing ventilator-related event infections in the Anesthesia and Reanimation-II Intensive Care Unit.

$H_{0\text{-}3}$: Nurses of Anesthesia and Reanimation-II Intensive Care Unit do not comply with bundle study.

$H_{1\text{-}3}$: Anesthesia and Reanimation-II Intensive Care Unit nurses comply with bundle work.

Materials and Methods

Study setting and Samples: This study was carried out in the ICU of a Department of Anesthesiology and Reanimation of a training and research hospital located in a metropolitan city of Turkey, between January 1 and March 31, 2019. All patients connected to the ventilator for at least two days in the relevant ICU between the dates of the study were included in the study. The period of the study included a total of 354 ventilator-days, 38 patients.

VAP Definitions

The new diagnostic criteria enabled us to separate VAE, ventilator-associated infections, and ventilator-associated complications. Besides, VAE allowed the National Healthcare Safety Network (NHSN) to make a multicenter comparison and to obtain more objective surveillance data. Diagnostic criteria for VAE separates the extent of the infection stage-by-stage (Table 1) (T. C. Ministry of Health, General Directorate of Public Health. National Healthcare Related Infections Surveillance Guide, 2017).

Table 1 Diagnostic criteria for VAE

VENTILATOR-ASSOCIATED EVENT (VAE)	**VAC**	Minimum daily FiO_2 increase of 20 points for ≥ 2 calendar days
	IVAC (Infection Related Ventilator-Associated Complications)	**VAC** + temp >38^{0}C or <36^{0}C or WBC ≥12 000 cells/mm3 or ≤4 000 cells/mm3 + a new antimicrobial agent(s) is started and is continued for ≥ 4 calendar days
	PVAP	**VAC + IVAC +** purulent respiratory secretions or positive culture for sputum, ETA, BAL, lung tissue, or protected specimen brush
	PVAP plus (High Possible Ventilator-Associated Pneumonia)	**VAC + IVAC +** purulent respiratory secretions or positive culture for sputum, ETA, BAL, lung tissue, or protected specimen brush (corresponding quantitative or semi-quantitative result) **OR** One of the following (without requirement for purulent secretions): Positive culture for pleural fluid Positive lung histopathology Positive diagnostic test for Legionella species Influenza in respiratory secretions, positive diagnostic tests for RSV, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus

Data Collection

Data collection tools were developed in light of the CDC criteria, guidelines prepared by the General Directorate of Public Health affiliated to Republic of Turkey Ministry of Health, and literature review (Cocoros and Klompas, 2016; Jansson et al., 2017; Guess et al., 2017; Kerlin et al., 2017; T. C. Ministry of Health, General Directorate of Public Health. National Healthcare Related Infections Surveillance Guide, 2017; Willson et al., 2018; Erfani et al., 2019; Meagher et al., 2019; Neef et al., 2019; Younan et al., 2019; Zigart et al., 2019). The study was performed through three forms. Form I that includes sociodemographic characteristics of the nurses, while Form II encompasses pre-test and post-test questionnaire to measure the nurses' level of knowledge on prevention VAE, and Form III consists of follow-up form for VAE prevention bundle. To evaluate its content validity, knowledge test (highest score:100, lowest score:0) in Form II was examined by a faculty member and four infection control nurses, who were experts in their fields. The content validity index of the questions was calculated as 0.99 (significance level, α =0,05).

Intervention

The implementation process of the research consists of three steps: analysis of VAE results in ICU and preparing VAE bundles, bundle training, and implementation of the research.

First step; VAE results were analyzed in the relevant intensive care unit, and bundle parameters were determined. Examining VAE results of ICU regarding the period of July 1 and September 30, 2018 (Third Quarter), the rates of

VAC and IVAC and PVAP were found to be as 14.2 and 3.56, respectively. In light of results analyzed, a bundle application was suggested to prevent VAE infections. It was decided to plan the research between October-December 2018, and to conduct the research between January 1 and March 31, 2019.

VAE prevention bundle parameters were determined in light of the CDC criteria, CDC guidelines, guidelines prepared by the General Directorate of Public Health affiliated to Republic of Turkey Ministry of Health, and literature review. Opinions of one infection control doctor and four infection control nurses, who were experts in their fields, were asked (Cocoros and Klompas, 2016; Jansson et al., 2017; Guess et al., 2017; Kerlin et al., 2017; T. C. Ministry of Health, General Directorate of Public Health. National Healthcare Related Infections Surveillance Guide, 2017; Willson et al., 2018; Erfani et al., 2019; Meagher et al., 2019; Neef et al., 2019; Younan et al., 2019; Zigart et al., 2019) (Box 1).

Box 1VAE prevention bundle parameters

1. Head of the bed elevation should be at an angle of 30-45 degrees
2. Use of an oral chlorhexidine rinse
3. Aseptic aspiration should be applied
4. The ventilator circuits are not dirty

Second step covers of the preparation of learning content for VAE prevention bundles. The training in question was prepared by the researcher in light of the relevant literature, to give ICU nurses (T. C. Ministry of Health, General Directorate of Public Health. National Healthcare Related Infections Surveillance Guide, 2017; Cheng Chao et al., 2018; Harris et al., 2018; Hebert et al., 2018; Dexter and Scott, 2019; Kallet, 2019; Klompas, 2019; Kubbara et al., 2019; Rello et al., 2019; Younan et al., 2019; Ziegler et al., 2019).

Expert opinion was taken regarding the training content prepared. Content validity indices for each item were calculated as 0, 99 (significance level, α =0,05). Training for VAE prevention bundles was initiated in December 2018, and training was progressed in different days and hours to allow active participation of all nurses.

Third step covers the implementation process of the study. First of all, prior to January 1, 2019, the starting date of the study, a 20-day compliance period was applied in the relevant ICU, and the compliance percentage was found as 70%. During this compliance period, bundle parameters were told by applying at the bedside and the questions of the nurses were answered by the researcher. In the relevant ICU, VAE diagnoses were determined by infection control nurses and recorded in the National Nosocomial Infections Surveillance System, and an inventory was taken out in certain periods.

Ethical considerations: Ethical approval (60/25) was obtained from the Ethics Committee of Ankara Dışkapı Yıldırım Beyazıt Training and Research Hospital to evaluate the ethical compliance of the study. Consent was taken from the nurses in the relevant ICU, who participated in the study. The ICU physician informed the patients in the ICU or their relatives about following the patients connected to a ventilator.

Statistical analysis: IBM SPSS Statistics 20.0 program (2015-IBM-SPSS Statistics Standard Pack 21 V: IBM Corp.) was used for statistical analysis and calculations in the study. For all the patients, who were connected to ventilators and included in the study between January 1 and March 31, 2019, the compliance rates were found. In the study, the pre- and post-training score distributions of the nurses were examined using the Wilcoxon test. Besides, of the variables in introductory information; mean±standard deviation was used for normally distributed continuous variables, while min-max for non-normally distributed variables, and number (%) values were used for categorical variables.

Results

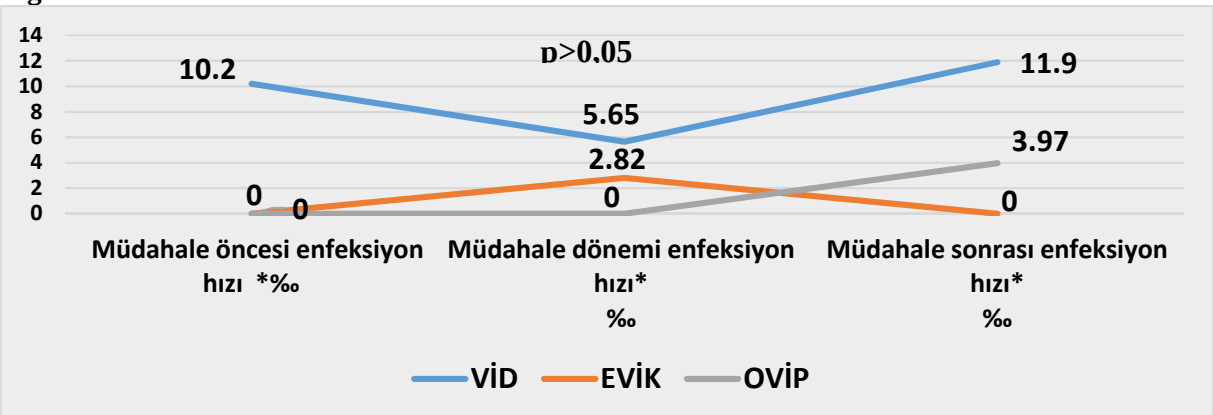
Characteristics of the participants: Of the nurses participated in the study, their ages were ranged from 25 to 40 (32,63±6,04 years in average), 87.5% (n=8) were female. All the nurses participating in the study received HAI prevention training in 2018, at the hospital they worked. It was observed that pre- and post-training score difference significantly increased (p<0,05, p=0,011) (Table 2).

VAE bundle compliance: VAE prevention bundle general compliance in the ICU was found as 85%. Bundle parameters' compliances, on the other hand, were found to be 75% for head of the bed elevation at an angle of 30-45 degrees, 81% for the use of an oral chlorhexidine rinse, 75% for applying aseptic aspiration, and 100% the ventilator circuits are not dirty. The intervention period of the study included a total of 354 ventilator-days, 38 patients. The total number of interventions made during the ventilator-day followed up was found as 13.452, with the product of the number of patients connected to the ventilator and the ventilator-days. Although no statistical significance was found in the study, it was seen that the rate of VAC reduced during intervention while the rate of Infection Related Ventilator-Associated Complications (IVAC) reduced in post-intervention period (Figure 1) (p>0,05). Besides, the rate of infection was found to reduce in the post-intervention period compared to pre-analytical phase of the study. While no difference was found between pre- and post-intervention period in the study, it was noteworthy that the number of patients increased in the post-intervention period but ventilator-days reduced (Table 3).

Table 2: Distribution of nurses' responses to the knowledge test

Nurse (n=8)				
Knowledge test	$\bar{X}$ ±SD	Min-Max	Wilcoxon Test	
			Z	p
Pre-training score distribution	5,75±0,8	4-7	-2,558	0,011
Post-training score distribution	7,75±0,4	7-8		

Figure 1 : Infection Rates Before and After the VAE Bundle



* Number of infections/ventilator days in operation) x1000

Table 3: Distribution of the number of patients, patient days and ventilator usage days before and after VAE prevention bundle

ICU	Pre-intervention period (October-December 2018)	Intervention period (January-March 2019)	Post-intervention period (April-June 2019)
Number of patients	30	38	86
Patient days	551	553	546
Ventilator-days	391	354	252

Discussion

Thanks to the introduction of new diagnostic criteria for invasive device-related infections in Turkey, definitions of ventilator-associated infections have changed, and ventilator complications and infections were separated. This research is the first study in bundle applications for VAE infections in Turkey.

When bundle parameters, which were determined among evidence-based infection control measures, are applied on the basis of "all-or-none principle", they make positive impacts on the rates of infection (Cheng Chao et al., 2018; Dexter and Scott, 2019). In this sense, training of nurses who work one-on-one with patients on bundle parameters increases the rate of compliance in practice. In this study, training was provided to nurses before the implementation. Thanks to the knowledge test applied before and after the training, post-training success was observed to significantly statistically increased (Table 2).

According to new diagnostic criteria for VAE, the first criterion to be met is the rate of VAC. VAC reflects the patient's lung condition rather than infection (T. C. Ministry of Health, General Directorate of Public Health. National Healthcare Related Infections Surveillance Guide, 2017). The higher VAC rate refers to a susceptibility to infection and an increase in ventilator-days. In the study, low rates of VAC in the intervention period indicates that patients with more stable lung condition are followed up in the ICU. Thanks to the study, awareness for infection of IVAC, the step following the VAC, was provided in the nurse group, in particular, and it was observed that the infection rate was zero out in the post-intervention period. Nurses' care with evidence-based practices reflected in the rate of infection. Examining PVAP infections in the study, an increase in direct proportion to the rate of VAC was observed. This case shows that in the post-intervention period in the ICU, patients with lung disorder are followed up clinically (Figure 1).

Besides, the denominator is the ventilator days when calculating the density of infection. In the study, the decrease in ventilator days in the post-intervention period compared to the pre-intervention period caused the result in density calculation to increase (Table 3). This should not be perceived as a negative effect, on the contrary, the reduce of ventilator days should be interpreted as increased awareness for patients to wean from the ventilator in a short time.

The first one of the bundle parameters in the study is the head of the bed elevation at an angle of 30-45 degrees. In the VAE prevention-purpose studies, a decrease in aspiration risk and a significant reduction in the rates of IVAC and PVAP, in particular, was observed when the head of the bed elevation is set correctly (Guess et al., 2017; Cheng Chao et al., 2018; Erfani et al., 2019; Kubbara et al., 2019). Ensuring the head of the bed elevation in the ICU reveals the quality of nursing care. In this study, awareness was given to nurses about the head of the bed elevation, and compliance with the relevant parameter was observed as 75%.

The second parameter of the study is the use of an oral chlorhexidine rinse. Thanks to its characteristics such as long-term antibacterial effects, ability to bind to oral tissues, and being an excellent antiplaque agent, chlorhexidine gluconate is an indispensable solution especially for patients connected to a ventilator (T. C. Ministry of Health, General Directorate of Public Health. National Healthcare Related Infections Surveillance Guide, 2017; Cheng Chao et al., 2018; Rello et al., 2019). A study conducted with 273 cases has shown that regular oral care with

chlorhexidine made a significant positive difference on the rates of VAE (Harris et al., 2018). In this study, regular oral care with chlorhexidine by nurses and 81% compliance with the bundle parameter indicates nurses' awareness of infection control measures. The third parameter of the study is aseptic aspiration. It is known that non-aspiration techniques pave the way for 80% of resistant infections, especially in the ICUs (Dexter and Scott, 2019). Studies have revealed that the maintaining of aseptic techniques while performing aspiration has a significant effect especially on IVAC and PVAP infections in VAE (Guess et al., 2017; Dexter and Scott, 2019; Erfani et al., 2019; Ziegler et al., 2019). In our study, the fact that nurses performed aseptic aspiration during the daily patient care in accordance with the needs of the patient and during the day showed a significant decrease in the rates of IVAC as well as 75% fit for the relevant parameter. The fourth parameter of the study is that the ventilator circuits are not dirty. Soiled ventilator circuits poses a risk for resistant bacterial colonization (Dexter and Scott, 2019). Studies have shown that keeping ventilator circuits clean has a significant impact on IVAC and PVAP infections (Guess et al., 2017; Dexter and Scott, 2019; Erfani et al., 2019; Ziegler et al., 2019). In this study, the nurses fully adapted to the relevant parameter. An effective infection control program is required to prevent invasive device-related infections in the ICUs. In terms of VAE infections, in addition to the clinical condition of the patients and medical care, providing of nurses, who work one-on-one with patients for 7 days 24 hours, a quality and evidence-based nursing care to patients has a significant effect on the rate of infection. As with nurses serving in all patient care fields, evidence-based and effective nursing care practices of intensive care nurses, in particular, is the key to infection control.

Limitations: To conduct the study in the ICU of a Department of Anesthesiology and Reanimation of a training and research hospital located in a metropolitan city in the Central Anatolia Region of Turkey is the limitation of this study.

Conclusion: Many factors such as patient-nurse ratio, ICU medical conditions, shortage of medical supplies, as well as training of health professionals, are of great importance in bundle practices. A comprehensible training program and subsequent inspections ensures behavioral changes in healthcare professionals. This study has revealed that VAE prevention bundle practices have affected the rates of infection.

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