

# Review Paper: The Bed Incline and Prevention of Ventilator-Associated Pneumonia



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## ABSTRACT

**Background:** Ventilator-Associated Pneumonia (VAP) is the most common nosocomial (hospital acquired) infection among patients undergoing mechanical ventilation. It increases mortality rate, duration of mechanical intubated ventilation, and hospitalization in the Intensive Care Units (ICUs). This review study aims to determine the proper gradient of a hospital bed in preventing VAP in patients hospitalized in ICUs.

**Methods:** In this study, research articles published from 1999 to 2016 were searched in PubMed, Science Direct, SID, and library sources, using keywords of “ventilator-associated pneumonia” and “elevated bed incline” and their corresponding terms in the Persian language.

**Results:** Results of the review showed that limited studies have been conducted on comparing the different inclines of bed and their effects on preventing VAP. Also, the available studies had methodological limitations or hospital staff failed to keep the patient in the same bed incline which was under the study for prolonged duration. Based on 19 reviewed studies, the incidence of VAP, hospital costs, mortality rate, and duration of mechanical ventilation in patients whose beds were inclined at 45 degrees or 30-45 degrees were significantly lower compared to patients reclining in the supine position. Although, in most conducted studies there were no consensus over a suitable bed incline in prevention of VAP and bedsore.

**Conclusion:** Raising the incline of bed can play a role in lowering the incidence of VAP, mortality rate, hospital costs and duration of mechanical ventilation. However, the proper gradient is not definite and requires studies with proper methodology in this regard.

## Keywords:

Ventilator-associated pneumonia, Elevated head of bed, Pressure ulcer, Intensive care unit



## 1. Introduction

entilator-Associated Pneumonia (VAP) is the most common hospital acquired

infection and its incidence varies between 9% and 67% (Akin Korhan et al. 2014). VAP is an acquired pneumonia that develops in patients who have been undergoing mechanical ventilation for more than 48 hours

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(Taraghi et al. 2011). In other words, VAP and duration of mechanical ventilation increase mortality rate, and hospital costs, the stay at Intensive Care Units (ICUs) (Metheny et al. 2010). VAP is diagnosed with infiltration and the systemic symptoms of infection (including fever and elevated white blood cells and changes in sputum characteristics) (Niel-Weise et al. 2011).

Seven principal factors that can lower the incidence of VAP include elevating the head of the bed, rinsing the mouth with chlorhexidine, prophylaxis to prevent thrombosis, washing hands and preventing aspiration, reducing use of sedative drugs, and early weaning from mechanical ventilation. Therefore, one of the interventions that are normally carried out regarding patients undergoing mechanical intervention is to elevate head of bed relative to the flat surface and positioning the patient at a 30-degree angle or more relative to the supine position (Palmer et al. 2001). Because of VAP risk, it is recommended that the bed incline be set at 45 degrees. Others recommend that the head of bed should be elevated at 30 to 45 degrees (Bankhead et al. 2009). European Assembly of Experts has recommended that head of bed should be raised 20 to 45 degrees and preferably more than 30 degrees (Niel-Weise et al. 2011).

Based on Kollef et al. study (1997), the supine position (equal to or less than 30-degree incline) is a risk factor and may lead to VAP and even death in patients undergoing mechanical ventilation. They reported a significant correlation between the bed incline and incidence of VAP (Grap et al. 2005). A clinical trial study on comparing two bed inclines of 0 and 45 degrees showed a significant difference between them with regard to VAP incidence. Based on these study results, clinical guidelines recommended to use an incline of 30 degrees and more for prevention of VAP in patients on mechanical ventilation, and observing this instruction became a common instruction of nursing cares (Drakulovic et al. 1999).

In another study, a negative correlation was observed between incline of bed head and indexes of acute physiology and chronic health evaluation (APACHE II, a severity-of-disease classification system, Knaus et al., 1985, one of several ICU scoring systems. It is applied within 24 hours of admission of a patient to an intensive care unit: an integer score from 0 to 71 is computed based on several measurements; higher scores correspond to more severe disease and higher risk of death. The first APACHE model was presented by Knaus et al. in 1981). It was also reported that the incline of bed head of patients undergoing mechanical ventilation was lower than those having spontaneous

breathing (Hanneman & Gusick, 2005). In this regard, Grap et al. (2003) reported that the mean elevation of head of bed of 170 patients in ICUs was 19.2 degrees and its observation and follow up were poor. A study on 66 patients in critical condition showed that in 72% of occasions elevating the bed incline of less than 30 degrees was kept just for one day.

On the other hand, the clinical guidelines regarding preventing pressure ulcers have recommended that the bed incline should not be more than 30 degrees because elevating more than 30 degrees leads to an increase in shear force (Shearing forces are unaligned forces pushing one part of a body in one direction, and another part of the body in the opposite direction. When the forces are aligned into each other, they are called compression forces) and accordingly development of pressure ulcer. To limit this effect, especially in the sacral region, clinical guidelines have recommended that the bed incline should be less than 30 degrees (Schallom et al. 2014).

Although there are few studies available regarding the effect of bed incline on development of pressure ulcer as compared with VAP (Metheny et al. 2010), in a study on 20 healthy volunteers it was found that the maximum pressure in the sacral region was at the 45-degree incline ( $P < 0.001$ ). However, the low-air-loss mattresses significantly reduce the pressure in all inclines (Lippoldt, Pernicka & Staudinger, 2014) ( $P < 0.001$ ). Pressure ulcer is often a complication of bed rest and patients hospitalized in ICUs are more prone to develop these types of injuries (Hyun et al. 2014). Considering the high incidence of bedsore in patients hospitalized in the intensive care units, paying attention to both issues and the proper bed incline seems necessary for their prevention.

Differences in clinical guidelines on the issue of VAP and pressure ulcer challenge health care staff regarding how to prevent both these costly hospital-acquired complications. Therefore, considering the conducted studies, the proper gradient of the bed for lowering the incidence of VAP and pressure ulcer in a patient hospitalized in ICU undergoing mechanical ventilation is not conclusive (Jackson et al. 2011). As a result, more studies should be conducted to examine the incidence of pneumonia and pressure ulcer at different inclines of the patient's bed, especially in patients hospitalized in ICUs undergoing mechanical ventilation and or having NG-tubes (Metheny et al. 2010).

However, most studies on the effect of semi-upright position in prevention of VAP and aspiration were done

in previous decades with small sample sizes and did not compare different bed inclines which would help determine the proper bed incline (Metheny et al. 2010, Niel-Weise et al. 2011). In this regard, it seems that a review study needs to be conducted for identifying the process of studies on proper bed incline and prevention of VAP and pressure ulcer, their methodologies, limitations and eventually arriving at a decision regarding the proper incline of bed to prevent VAP and pressure ulcers (systematic review - a type of literature review that collects and critically analyzes multiple research studies or papers).

Likewise, a meta-analysis study was conducted to determine the impact of patient's reclining position on the incidence of pneumonia. In this analysis, 7 randomized clinical trial studies with a control group were examined. Results of the review study showed that the incidence of pneumonia among patients who were at 45-degree in-

cline position was significantly lower than patients who were in the supine position (Alexiou et al. 2009).

Another systematic review compared 3 randomized clinical trial studies with the control group and reported that the impact of 45-degree incline on the incidence of VAP was not conclusive and further investigations were needed in this regard. In addition, the researchers stated that there was insufficient information on the advantages and disadvantages of the using 45-degree bed incline for the patients undergoing mechanical ventilation was dependent on many factors (Niel-Weise et al. 2011).

Based on the latest review by Leng et al. (2012), the incidence of VPA among patients at 45-degree incline was significantly lower than patients with lower incline of their beds. However, whether this incline could have priority over other inclines, required more extensive

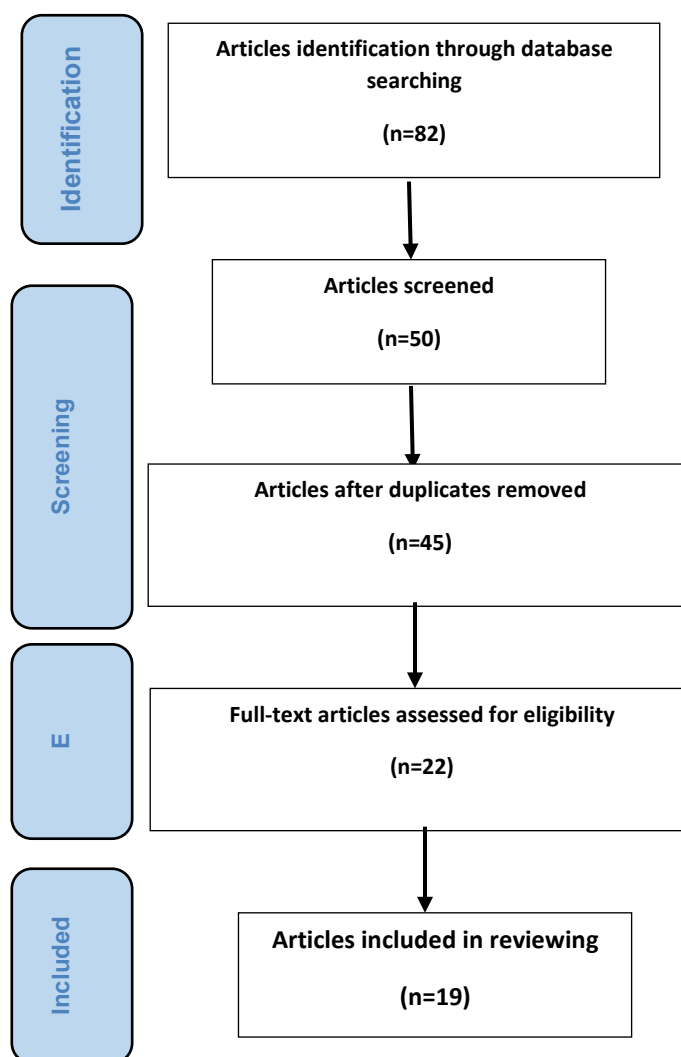


Figure 1. Search flowchart selection and articles' review

studies. The following questions were considered in this review study:

1. In the studies, what bed inclines were examined for prevention of VAP and pressure ulcer, and what were the results?
2. How do health care workers observe proper bed incline for prevention of VAP and pressure ulcer and what factors were associated with it?

## 2. Methods

### Data source and search method

This study examined and reviewed the studies conducted from 1999 to 2016 regarding the proper bed incline to prevent VAP through search and extraction from SID, PubMed, and Science Direct. Furthermore, library catalogue search, the reference control method, and also inquiries from experts on the research topic were sought and used. In this review, the keywords were “ventilator-associated pneumonia,” “elevation,” “head of bed,” “pressure ulcer,” “intensive care units,” and their Persian equivalents which were searched in the titles and abstracts.

These keywords were chosen by two experts in Nursery, and one of them searched the phrases related to proper bed incline in preventing VAP in databases. Then, another colleague re-examined and searched the sources and databases to be ensured of the adequacy of searched information and articles. This colleague who searched and extracted the articles were blind regarding the authors, the institutes, and the magazines that were subject to search.

### Criteria for selecting the articles

Research articles were selected in both Persian and English articles on the prevention of VAP and pressure ulcer in ICUs that were published between 1999 and 2016. Articles that did not refer to the role of bed incline on the prevention of VAP, or referred to patients who were not undergoing mechanical ventilation were excluded from the review process.

Results of the search included 82 articles, out of which 45 articles covered the study subject, and by eliminating duplicate materials in different websites, 19 articles were found qualified for the review. Inclusion criteria comprised topics in connection with the bed incline in preventing VAP and pressure ulcer and articles referring to clinical guidelines on bed incline in preventing VAP and pressure ulcer. [Figure 1](#) shows the search flowchart of selection and review of articles.

### Method for selecting the articles

To determine the suitability of articles, first the title and the abstract of the articles were examined along with the time of study, then for further examination, all articles texts were studied by one of the researchers.

Thereupon, the following information was extracted by another researcher from the selected articles: type of the study, the hospital ward at which the study was carried out, and the year the study was conducted, sample size and method, statistical analysis and results of the study. The resulting information was evaluated by researchers and approved by resolving disputes through negotiations. A summary of the articles features are given in [Table 1](#).

### Features of reviewed studies

#### Type of study

Assessment of knowledge in 2 studies, performance of nurses in 1 study, comparing different bed inclines in prevention of VAP in 14 studies, investigating the feasibility of elevating the bed incline in 1 study, and the programs for combining the bed incline with other methods in prevention of VAP in 5 studies were examined. Study methods comprised randomized control, prospective, descriptive, and retrospective.

#### Study population and sample

Four studies concentrated on the performance and knowledge of nurses working in ICUs, and other studies were conducted on patients hospitalized in ICUs undergoing mechanical ventilation. With regard to sample size, most studies had a sample size of less than 100 persons.

#### Data collection method and tools

Out of the articles, 3 studies had used the checklist for registering the mortality rate and duration of hospitalization. Most studies used the clinical pulmonary infection scoring (CPIS) for investigating the incidence of VAP. Scoring system of this tool is presented in [Table 2](#). Other studies have used bacterial cultures, Hunter diagnostic criteria (similar to CPIS) and pepsin reagent strips, for identifying aspiration.

CPIS tool ([Table 2](#)) was discussed for the first time by Pugin et al. It includes six parameters: 1) temperature, 2) white blood cell count, 3) presence or absence of pulmonary secretions, 4) PaO<sub>2</sub>/FiO<sub>2</sub> ratio, 5) chest X-ray, and 6) results of smear and sputum culture with the semi-quantitative method. Each parameter has the score

**Table 1.** List of the studies conducted on the bed incline and VAP in patients hospitalized in ICUs between 1999 and 2016

No.	Study Title	Author	The Study Type	Sample Size	Instru- ment	Results
1	Supine position, a risk factor for ventilator-associated pneumonia: a randomized study	Drakulovic et al. 1999	Randomized clinical trial with control group	86 patients in 2 groups of supine position and 45 degrees (semi upright position)	Clinical pulmonary infection score and Braden scale	Pneumonia was significantly lower in the semi-upright position. The highest incidence of pneumonia was reported in patients in supine position and having NG-tube. No incidence of pressure ulcer was reported.
2	Nursing care in prevention of ventilator-associated pneumonia	Elorza Mateos et al. 2011	Descriptive	26 patients	Clinical pulmonary infection score	Oral hygiene was observed in 23 patients. In 20 patients, mean elevation of bed was more than 30 degrees. In 19 patients, the endotracheal tube cuff pressure was greater than 20 mmHg. As a result of these measures and also elevating head of bed by approximately 30 to 45 degrees, the incidence of pneumonia significantly reduced.
3	The impact of a protocol to reduce the level of aspiration	Metheny et al. 2010	Quasi-experimental	474 patients: 145 patients in 30 degrees incline, 329 patients in the control group	Clinical pulmonary infection score	The combination of elevating the bed more than 30 degrees and use of feeding tube in the small intestine significantly reduced the incidence of pneumonia.
4	Using multiple cares to prevent VAP	Narang 2008	Retrospective	240 patients	Clinical pulmonary infection score	Using multiple cares such as elevating the bed incline by about 30 to 40 degrees, and prophylaxis for preventing stomach ulcer and deep vein thrombosis, significantly reduced pneumonia. Duration of ventilation also reduced.
5	Aspiration of stomach contents in critically ill patients with NG-tubes	Metheny et al. 2006	Prospective	360 patients: 124 patients with the bed incline more than 30 degrees, and 226 patients with the bed incline less than 30 degrees	Pepsin reagent strips	In less than 30 degrees incline, patients had a higher percentage of aspiration, and this difference was not significant. Also, in these patients, the incidence of pneumonia was significantly higher. The percentage of pepsin-positive trachea tube secretions was also higher in these patients. As a result, the bed incline of less than 30 degrees is a risk factor for developing aspiration and pneumonia.
6	Predictors of elevating the bed	Grap et al. 2003	Descriptive	160 patients	Clinical pulmonary infection score	Most patients were in the supine position (71%) and a few were lying face down (1%). There was a significant association between elevating the bed and the systolic and diastolic blood pressure. Regarding elevating the bed, there was no association between patients with NG-tubes with patients without NG-tubes. The difference regarding elevating the bed was associated with mechanical ventilation. In patients under mechanical ventilation, the bed incline was lower than the other patients.



No.	Study Title	Author	The Study Type	Sample Size	Instru-ment	Results
7	Possibility and the impact of 45-degree incline (semi-upright position) in preventing ventilator-associated pneumonia	van Nieuwenhoven et al. 2006	Prospective	109 patients in the supine position and 112 patients in the semi-upright position (45 degrees)	Cultures obtained by bronchoscopy	Ventilator-associated pneumonia was reported in 8 patients in the supine position, and in 13 patients in the semi-upright position. The mean of elevating the head of bed was 9.8 degrees and 16.1 degrees on the first day and seventh day in the group in the supine position, respectively and 28.1 degrees and 22.6 degrees in the first and seventh day for the group in the semi-upright position, respectively (P < 0.001). The 45-degree bed incline was not achieved in 85% of study duration and these patients had much more change of positions than patients in the supine position.
8	Elevating the bed and its impact on stomach reflux, aspiration, pressure ulcer	Schallom et al. 2014	Crossover	15 patients, 8 patients in the intervention group (45 degrees) 7 patients in the control group (30 degrees)	Pepsin reagent strips for oral and tracheal secretions, the Braden Scale	188 samples of oral secretions were obtained, of them 44% were pepsin-positive (pepsin-positive secretions indicate reflux). 174 samples of tracheal tube secretions were also obtained, of which 62% were pepsin-positive (pepsin-positive secretions are signs of aspiration). In the 30 degrees incline, pepsin positive oral secretions were 48.8% as compared with 32.3% in the 45 degrees incline, and statistically, this difference was not significant (P = 0.11). At 30-degree incline, pepsin-positive tracheal tube secretions was 69.4% as compared with 62.5% at 45-degree incline, and this difference was not statistically significant (P = 0.37). No incidence of pressure ulcer was observed. Therefore, patients by using wavy mattresses at 30 degrees or more inclines, can stay in bed for 12 to 24 hours without suffering from pressure ulcer.
9	Lowering the incidence of ventilator-associated pneumonia through elevating the head of bed	Keeley 2007	Randomized clinical trial with the control group	30 patients entered into this study, of them 17 patients were placed in the 45-degree incline and 13 patients in the 25-degree incline	Microbiological testing of clinical symptoms	Statistical results showed that 5 patients out of the 45-degree group and 7 patients out of the 25-degree group became affected by ventilator-associated pneumonia, and there was a tendency of mitigation of pneumonia in patients positioned in the 45-degree incline, although the difference was not statistically significant.
10	The semi-upright position in patients connected to mechanical ventilation	Rose et al. 2010	Prospective	371 patients	Clinical symptoms, Criteria of Center for Disease Control, Microbiological tests, 1SOFA (Sequential (or Sepsis) Organ Failure Assessment score)	Pneumonia was reported in 12 patients (3.2%). During 7 days of study, 2112 observations were made. The 45-degree incline position or more was seen in 112 observations (3.5%). In 22.3% of the occasions, the bed incline was kept between 30 to 45 degrees. The 15-degrees incline or less was seen in 353 instances (16.7%). The head of bed was elevated mostly when the patient was being weaned from the mechanical ventilation and was fed. Also, the bed incline was mostly lowered in connection with using inotrope agents and the lowering of the mean arterial pressure. The bed incline was also lower in patients who were in critical conditions.

No.	Study Title	Author	The Study Type	Sample Size	Instru- ment	Results
11	Effective factors on the bed incline in the cardiac surgery intensive care units	Ballew et al. 2011	Descriptive	100 patients	SOFA	The head of bed was mostly lowered when using vasopressor agents and hemodynamic supportive factors. Patients whose mean arterial pressure was 64 mmHg, their head of bed was lower.
12	The combination of subglottic secretions drainage and semi-upright position for prevention of VAP	Chen et al. 2016	Prospective	124 patients: 40 patients in the semi-upright position, 39 patients in the subglottic secretions drainage group, 43 patients in the semi-upright position and subglottic secretions drainage group, and 42 patients in the control group	Hunter diagnostic criteria	The incidence of ventilator-associated pneumonia has been reduced in three intervention groups. Also in the intervention group, there were fewer instances of ventilator-associated pneumonia; however, there were no significant difference between the groups regarding the mortality rate resulting from ventilator-associated pneumonia.
13	The effect of elevating bed on the prevention of ventilator-associated pneumonia	Grap et al. 2005	Descriptive	Examining 66 patients under mechanical ventilation for 7 days, a total of 276 observations	Clinical pulmonary infection score	The mean elevation of head of bed in the entire study was 21.7 degrees. Elevating the head of bed did not have a direct effect on clinical pulmonary infection score. Incidence of pneumonia was higher among patients who were in critical condition and were positioned in an incline of 30 degrees on the first day of mechanical ventilation.
14	Impact of care plan on the prevention of ventilator-associated pneumonia	Ferreira et al. 2016	Prospective	188 patients	Checklist	After implementing the checklist items, the incidence of ventilator-associated pneumonia, hospital costs, and mortality significantly reduced ( $P < 0.01$ ).
16	Education alone is not sufficient to prevent ventilator-associated pneumonia. Multiple cares are required.	Hamishehkar et al. 2014	Observational	552 checklists, including 294 observations prior to training and 258 observations after training	Checklist	Mean instances of ventilator-associated pneumonia before training was 36.5% and after training was 41.2%. The bed incline of half of the patients in both groups was less than 30 degrees prior and after training. Half of nurses in the wards did not know that the bed incline between 30 and 45 degrees was important in prevention of pneumonia.
16	The effect of care programs for upper respiratory system in prevention of VAP in patients hospitalized in the intensive care units	Bakhtiari et al. 2015	Randomized clinical trial with the control group	62 patients: 35 patients in the intervention group and 37 patients in the control group	Clinical pulmonary infection score	On the fifth day, the incidence of ventilator-associated pneumonia significantly reduced in the intervention group (elevating head of bed by about 45 degrees, drainage of subglottic secretions, rinsing the mouth with chlorhexidine 2%, and measuring the cuff pressure up to 25 cm of water).

No.	Study Title	Author	The Study Type	Sample Size	Instru-ment	Results
17	Knowledge of ICU nurses on prevention of ventilator-associated pneumonia	Korhan et al. 2013	Cross-sectional	138 ICU nurses in Turkey	The form of nurses' knowledge regarding clinical guidelines in prevention of VAP	The nurses' knowledge was very poor. About 29.7% of them stated that the semi-upright position was effective in prevention of ventilator-associated pneumonia.
18	Pressure exerted on body under different bed inclines with different kinds of wavy mattresses	Lippoldt et al. 2014	Prospective	20 healthy volunteers	Xsensor technology	The maximum pressure in the sacral area was in the 45-degree incline (P < 0.001); however, the low air-loss mattresses significantly lowered the pressure under all inclines (P < 0.001).
19	Comparing the effect of bed incline at 30 and 45 degrees in prevention of ventilator-associated pneumonia in patients hospitalized in the intensive care units	Najafi Ghezleji T et al. 2016	Randomized clinical trial with the control group	120 patients	Clinical pulmonary infection scoring	At the conclusion of the third day of intervention, the incidence of ventilator associated pneumonia was significantly lower among patients who were in the 30- and 45-degree bed incline (P < 0.001). Also at 45-degree incline, the incidence of ventilator-associated pneumonia was less than that in 30-degree incline. The three groups did not have any statistically significant difference with regard to being affected by bedsores.

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of 0, 1, and 2, except the PaO<sub>2</sub>/FiO<sub>2</sub> ratio which has the score of 0 and 2. Pugin and colleagues reported the sensitivity of tools as 93% and its specificity as 100% (Pugin et al. 1991). In most studies, digital or manual goniometer was used to measure the bed incline.

In a few studies, the simultaneous examination of pressure ulcer was also conducted. In these studies, Braden scale was used to anticipate pressure ulcer.

Only, in one study, the evaluation method of research tool has been reported with regard to its validity, reliability, sensitivity, and specificity (Akin Korhan et al. 2014). The Braden scale is used for anticipating pressure ulcer, and has been mentioned with 95% confidence interval in a study (Serpa et al. 2011).

Braden scale includes 6 parameters and each parameter has 4 sections. If total score of a patient is 16-18, it indicates low risk, 13-15 medium risk, 10-12 high risk, and less than 9 very high risk.

Every day, total scores for the patient should be computed and the patient' skin in pressure regions should be evaluated at each time his or her position changes, so that those patients at risk can be identified (Table 3).

### 3. Results

#### Knowledge and performance of ICU nurses and its related factors

A study conducted in Turkey with the aim of examining the level of knowledge of ICU nurses in prevention of VAP reported that the nurses' knowledge was very poor in a way that only 29.7% knew that 45 degrees incline of bed was effective in the prevention of VAP. They also reported that 68.80% of nurses were aware of the advantages of using closed suction system in prevention of VAP.

About 16.7% of nurses were aware of the time for changing the closed suction system in every patient and 23.90% of them were aware of the subglottic secretion drainage in prevention of VAP (Akin Korhan et al. 2014). Hamishekar et al. reported that training the nurses would not alone suffice to prevent VAP and multiple cares should be taken for patients undergoing mechanical ventilation to prevent VAP.

Therefore, the mean use of multiple cares to prevent VAP was 36.50% before training and 41.20% after training (P > 0.05). The bed incline for half of patients in both groups, before and after training, was less than 30 degrees. About 50% of nurses of ICUs did not know that the incline of 30-



Table 2. CPIS tool

Parameter	Value	Score
Temperature, °C	36.5 - 38.4	0
	38.5 - 38.9	1
	39 < , 36 >	2
White blood cell count	4000 - 11000	0
	11000 < , 4000 >	1
	500 < Band white blood cell	2
Pulmonary secretions	No pulmonary secretions	0
	Nonsuppurative pulmonary secretions	1
	Suppurative pulmonary secretions	2
Oxygenation: PaO <sub>2</sub> /FiO <sub>2</sub> ratio, mmHg	240 > or presence of ARDS (acute respiratory distress syndrome) symptoms	0
	240 < and absence of ARDS symptoms	2
Chest radiography	No infiltration	0
	Diffused infiltration	1
	Local infiltration	2
Smear and sputum culture by semi-quantitative method	No pathogenic bacteria in sputum culture (+ / 0)	0
	Pathogenic bacteria in sputum culture (+++ / ++ / +)	1
	Some pathogenic bacteria are seen in the smear	2

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Table 3. Braden Scale

Friction and Shear	Nutrition	Mobility	Activity	Moisture	Sensory Perception	Score
Without difficulty	Excellent	Without restriction	Often walks	Rarely moist	No impairment	4
Without apparent difficulty	Sufficient	Partial restriction	Occasionally walks	Occasionally moist	Partial limitation	3
Potential problem	Probably insufficient	Very restricted	Dependent on chair	Very moist	Very limited	2
Difficult	Very weak	Completely immobile	Dependent to bed	Consistently moist	Completely limited	1

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45 degrees was important and vital to prevent pneumonia. Most nurses reported that they did not have sufficient time to perform preventive cares of VAP and the treatment system had not sufficiently provided them with necessary training in this regard (Hamishehkar et al. 2014).

The effect of multiple cares in prevention of VAP has been examined in 5 studies. In these studies, a combination of different interventions were used to prevent

VAP. In one study it has been reported that combined elevation of bed incline more than 30 degrees and use of nasogastric feeding tube significantly reduced VAP incidence. Results of the study showed that using combination programs such as elevating the bed incline about 30-45 degrees, subglottic secretion drainage, rinsing the mouth with chlorhexidine 2%, and measuring the cuff pressure within 25 cm water, significantly

reduced the incidence of VAP (Elorza Mateos et al. 2011; Bakhtiari et al. 2015).

Although in a study, the mortality rate among the group receiving multiple cares did not have significant difference with the control group (Chen Guihua et al. 2016), a significant reduction in mortality rate and hospital costs was reported in another study (Ferreira et al. 2016). Furthermore, in another study, the effect of combined intervention was demonstrated on lowering the incidence of VAP, duration of mechanical ventilation, and upper gastrointestinal bleeding (Narang 2008). Based on another study, the target of 45 degrees incline was not achieved in 85% of study duration and the reclining position of these patients have been changed far more than in patients in the supine position (van Nieuwenhoven et al. 2006).

In one study, the mean level of bed incline was 19.2 degrees and 70% of patients were in the supine position. No difference was found with regard to the elevation of the bed incline for starting the feeding among patients with tracheal intubation as compared with patients without endotracheal tube (Grap et al. 2003). In two other studies, it was also reported that patients under mechanical ventilation and in critical condition had a lower bed incline as compared with other patients (Grap et al. 2003; Rose et al. 2010).

Also, another study results showed that the bed incline of patients receiving vasopressor drugs ( $P = 0.001$ ), patients under treatment with hemodynamic status supportive drugs (19 degrees vs. 26 degrees  $P = 0.01$ ), and patients with median arterial pressure of 64 mmHg or less (17 degrees vs. 24 degrees  $P = 0.01$ ) was lower than that of other patients. They demonstrated that the bed incline did not have any association with the nurses' working shifts, and lowering the patients' bed incline had no connection with the night shift. Grap et al. and Rose et al. in their studies came to this conclusion that the highest elevation of the bed incline was at the time of weaning the patient from mechanical ventilation and being fed.

Also, the greatest decrease in the bed incline was in association with the use of inotrope agents and lowering the mean arterial pressure. The reasons for not keeping patients at 45-degree incline included the nurses' inconvenience in carrying out cares, especially for critically ill patients at that incline, and also the difficulty in keeping the patients lying on their side (Grap et al. 2003; Rose et al. 2010). Other reasons for nurses' not observing the 45-degree bed incline included pa-

tients' inconvenience, fear of making pressure ulcers, lacking sufficient information about clinical guidelines about elevating the bed incline to prevent VAP (Ballew et al. 2011). In another study, the nurses reported that the health system did not provide them with sufficient training, and due to shortage of health staff, nurses did not have sufficient time to carry out the required cares for the patients (Hamishehkar et al. 2014).

### Comparing different bed inclines in prevention of VAP

Four studies reported that the incidence of VAP among patients at 45-degree bed incline was significantly lower than that in patients at lower inclines. Furthermore in several other studies, the inconclusive effect of 45-degree incline on VAP incidence and the need for further investigation in this regard were mentioned. Another study reported that in patients who were in lower than 30 degrees incline, the incidence of pneumonia was significantly higher (Metheny et al. 2006).

In another study, the highest incidence of pneumonia was reported in patients in the supine position as compared with patients at 45-degree incline and with NG-tube. It was also reported that there was an association between semi-upright position and reduction of VAP incidence in patients hospitalized in ICUs undergoing mechanical ventilation (Drakulovic et al. 1999).

In a study, 30 patients hospitalized in ICU under mechanical ventilation were randomly divided into two groups of intervention (45-degree incline) and control group (25-degree incline). The study result showed that 29% of patients in the intervention group and 54% of patients in the control group were affected by VAP, although the difference was not statistically significant (Akin Korhan et al. 2014). Bakhtiari et al. placed the patients in the intervention group under upper respiratory system care program, including keeping the patient at 45 degrees of incline. Endotracheal tube cuff pressure was also kept within the limit of 25 cm water, and prior to each position change, the tracheal tube secretions were suctioned off.

Until the fourth day, the incidence of VAP pneumonia did not show significant difference between the two groups; however, on the fifth day, the incidence of VAP in patients in the intervention group significantly reduced as compared with the control group (Bakhtiari et al. 2015). In Schallom et al. study, no statistically significant differences were observed between the 30- and 45-degree bed incline regarding the incidence of aspiration and bedsore.

Therefore, patients can be kept at 30 degrees or more incline by using low-air-loss mattresses, without occurrence of pressure ulcer. This study also suggested that keeping the patients at 30 degrees or more incline was feasible and easily tolerated by the patients and made no interference with performance of nursing cares. Prior to positioning the patients in the supine position or in the Trendelenburg position, nurses should examine and suction off the secretions of the mouth and trachea of the patients. Furthermore, patients receiving sedative drugs, should be positioned at least at 30 degrees of incline to reduce reflux and aspiration (Schallom et al. 2014).

In Najafi et al. study (2016), patients in the intervention group were positioned at 30-degree and 45-degree bed incline for three days but patients in the control group were positioned in the regular bed incline required by that hospital ward, and adjusted by nurses. Furthermore, all upper respiratory system and bedsore cares were carried out equally for all patients. Based on the results, the incidence of VAP significantly reduced among patients in the intervention group of 30- and 45-degree inclines ( $P < 0.01$ ) and the incidence of VAP at 45-degree incline was less than that in the 30-degree incline group. At the end of the third day, none of the patients in the intervention group (30- and 45-degree incline) contracted pressure ulcer (Najafi Ghezjeljeh, Kalhor & Haghani 2016).

Drakulovic et al. also investigated comorbidity of pressure ulcer with VAP incidence and concluded that patients at 45-degree incline had lower incidence of VAP and also no cases of pressure ulcer was reported in these patients (Drakulovic et al. 1999). However in Lippoldt et al. study on 20 healthy volunteers, the pressure exerted on various areas of the skin and sacrum and buttocks was measured at 0, 10, 30, and 45 degrees on 4 types of wavy mattresses and in 6 positions of the supine, lying on the side, lying face down, the Trendelenburg position, reverse Trendelenburg position, and semi-upright position. The bed incline was measured by electronic goniometer. Pressure exerted on the sacrum region increased only at 45-degree incline ( $P < 0.001$ ). The reverse Trendelenburg position led to the lowest pressure exerted on the sacrum region under all inclines ( $P < 0.01$ ) (In the Trendelenburg position, the body is laid flat on the back with the feet higher than the head by 15-30 degrees, in contrast to the reverse Trendelenburg position, where the body is tilted in the opposite direction.) . Heavier weight causes more pressure and more widespread contact of the body with mattresses and the use of low-air-loss mattresses also leads to distinct reduction of pressure. As a result, using low-air-loss mattresses accompanied with reverse Trendelenburg position and el-

evating the bed head by about 30 to 45 degrees are very appropriate for preventing skin damage in the sacral area (Lippoldt, Pernicka & Staudinger 2014).

#### 4. Discussion

In this review study, 19 articles were reviewed regarding elevating the bed incline in prevention of VAP and pressure ulcer. Our review shows the limitation of studies on examining the impact of bed incline elevation in prevention of VAP and pressure ulcer. The studies that had compared different inclines in prevention of VAP recommended a bed incline of 45 degrees. However in most studies, the method of operation and modality of examining the variables, data collection tools and the method of assessing the reliability and validity of tools were not fully explained. Some studies briefly mentioned CPIS (Clinical Pulmonary Infection Score) tools and the Braden scale, however, they made no attempt to explain these tools.

In line with this review, Alexiou et al. in a review of 7 clinical trial studies showed that the incidence of pneumonia among patients at 45-degree incline was significantly lower than patients in the supine position (27% vs. 47%) and the 15- to 30-degree incline was insufficient to prevent VAP in patients undergoing mechanical ventilation. Also, patients in 45-degree incline had a lower mortality rate compared with patients lying face down or in the supine position. However, the difference was not statistically significant (86% vs. 92%). Therefore, the 45-degree incline is one of the simplest and least costly methods for preventing VAP.

However, keeping the patients at 45-degree incline was difficult with regard to changing the patients' reclining position, and necessary training should be given to nurses about keeping the patients in this incline (Alexiou et al. 2009). Nevertheless, in Niel-Weise et al. review on 3 randomized clinical trial studies with the control group, the researchers did not have sufficient confidence in the advantages and disadvantages of the 45-degree incline and suggested further investigations in this regard. Also, the impact of elevating the bed incline to 45 degrees for 24 hours on the incidence of thromboembolism and hemodynamic instability is not clear (Niel-Weise et al. 2011).

Leng et al. in a meta-analysis showed that the incidence of VAP in patients at 45-degree incline was significantly lower than the control group (patients at a lower bed incline) ( $P = 0.001$ ). However, there were no significant differences regarding the mortality rate and

length of hospitalization in ICU and treatment with antibiotics (Leng et al. 2012). Some studies also showed no significant differences between 30-degree and 45-degree inclines. Other studies referred to the point that patients hospitalized in ICUs, by using low-air-loss mattresses, can be positioned at 45-degree incline without being affected by pneumonia and pressure ulcer (Lippoldt, Pernicka & Staudinger 2014).

The semi-upright position causes interference with nursing cares. Position change of patients to lying on their side was difficult for patients. Also nurses feared that patients could be affected by pressure ulcers. Whereas some studies have concluded that the semi-upright position was comfortably feasible by patients and had no interference with nursing cares. Some studies have also reported that the 15- to 30-degree incline was not sufficient to prevent VAP, and patients undergoing mechanical ventilation should be positioned at 45-degree incline.

The awareness of nurses of preventing VAP by elevating the bed incline was poor. However, the result was positive after performing multiple cares. Review of studies related to the impact of multiple care programs in prevention of VAP confirms the better effectiveness of these cares in VAP prevention. Using combined applications such as elevating the bed about 30-45 degrees, draining subglottic secretions, rinsing the mouth with chlorhexidine 2%, and measuring cuff pressure to within 25 cm water significantly reduces the incidence of VAP. In general, the following recommendations are offered for prevention of VAP:

- Keeping the bed incline at 30 to 45 degrees in patients undergoing mechanical ventilation and having NG-tube,
- Using wavy mattresses,
- Using noninvasive mechanical ventilation with positive pressure but with adequate precautions for patients with acute lung injury, acute respiratory failure, severe hypoxia, or severe acidemia,
- Using sedatives in low dosage,
- Daily examination of the patients to remove the endotracheal tube as soon as possible,
- Drainage of secretions above the endotracheal tube cuff,
- Maintaining the mechanical ventilation circuit and quickly changing it when fluid is seen in the circuit,

- Oral hygiene by using chlorhexidine and toothbrush twice a day,
- Peptic ulcer prophylaxis, and
- Continuous education and training of hospital staff on prevention and control of infection (Klompas et al. 2014).

Therefore, combination of these interventions in patients undergoing mechanical intervention should be emphasized and all nurses and physicians should be asked to carry out these cares. As such, more studies should be conducted in this field with larger sample sizes. Also, in many studies the feasibility and independent effect of 45-degree incline (semi-upright position) in prevention of VAP has not been examined yet. Some studies have reported that critically ill patients had lower inclined beds. Also, the patients' beds were mostly lowered at the time of weaning from the mechanical ventilator.

Regarding methodology, the conducted studies had some limitations. Some studies had small sample sizes. Also, in most studies blinding was not carried out (A blind — or blinded — experiment is an experiment in which information about the test is masked (kept) from the participant, to reduce or eliminate bias, until after a trial outcome is known. It is understood that bias may be intentional or unconscious, thus no dishonesty is implied by blinding. If both tester and subject are blinded, the trial is called a double – blind experiment) that could result in the Hawthorne effect (The Hawthorne effect, also referred to as the observer effect, is a type of reactivity in which individuals modify or improve an aspect of their behavior in response to their awareness of being observed.).

To prevent bedsore, the position of patients hospitalized in ICUs should be changed every two hours and as a result they may not be returned to the required bed incline. Resolving this issue needs exact measurement and recording of the bed incline. In some studies the bed incline was measured only three times a day and this can affect the accuracy of measuring the bed inclines and confidence in keeping the patients in those inclines. It is recommended that proper studies be conducted on continuous measuring the bed incline with digital tools, or using beds with incline marker. Also, in some studies that patients' beds incline was more than 30 degrees, a proper evaluation of patients' skin damage was not reported.

An exact method was not used for pneumonia diagnosis in most studies (such as bronchoscopy and preparation of sample for microbial culture). Since, in patients



undergoing mechanical ventilation, the VAP does not develop until after 48-72 hours, the VAP diagnosis criteria such as fever, leukopenia or leukocytosis, infiltration in chest X-ray and microbial cultures should be performed routinely that usually cost little. On the other hand, in most studies, investigating pneumonia incidence was conducted after 72 hours to 5 days. It is recommended that studies be conducted on the long-term effects of keeping patients in various inclines on the incidence of VAP and clinical implications.

Meanwhile, the performance of nurses in compliance with elevating the bed incline for patients undergoing mechanical ventilation depends on general policies of the hospital (Grap et al. 2003). In order to prevent VAP, it is suggested that training programs be prepared for nurses working in the ICUs, and risks of lowering the patients' bed incline be taught to ICU nurses. Furthermore, studies should be conducted with the aim of identifying problems in keeping elevated the bed incline for patients undergoing mechanical ventilation, and measures should be adopted to reduce or remove these problems.

## 5. Conclusion

Based on reviewing the relevant articles, bed inclines of 30 to 45 degrees are appropriate for patients undergoing mechanical ventilation with NG-tube, and significantly reduce the incidence of VAP and aspiration as compared with patients in the supine position.

According to this review, the more is the bed incline, the less is the probability of pneumonia, and the 45-degree incline is preferable. Thus, the supine position is a risk factor for VAP, and nurses should consider this issue when changing the patient's position, although the studies that have been conducted in this regard are limited and have several methodological difficulties. On the other hand, in most studies, the effect of the bed incline on both VAP and bed sore was not investigated. Therefore, more randomized clinical trial studies with the control group should be conducted to examine the effects of different bed inclines on prevention of VAP and pressure ulcer, especially in patients who are in critical condition and undergoing mechanical ventilation with NG-tube.

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## Conflicts of Interest

The authors of this study declared no conflict of interests.

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