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RESEARCH

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Role of head-of-bed elevation in preventing ventilator-associated pneumonia bed elevation and pneumonia

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Abstract

Background: Elevating the head of bed (HOB) to 30° to 45° is an evidence-based recommendation to prevent ventilator-associated pneumonia (VAP). However, the available scientific data are inconclusive regarding the optimal degree of HOB elevation which is safe and effective for mechanically ventilated patients.

Aims and objectives: To investigate the impact a of semirecumbent position at 30° and 45°on the development of VAP as compared with aHOB elevation to <30°.

Methods: A 5-day, single centre, prospective, randomized, controlled, parallel group, three-arm study was conducted in adult patients on mechanical ventilation staying in the intensive care unit. Patients were randomly placed in <30°, 30°, or 45° HOB elevation position on the day of intubation and followed up for 5 days. They were assessed in terms of the development of microbiologically confirmed VAP (by the culture of endotracheal aspirate) over the study period.

Results: Sixty patients (20 in each arm) completed the study. VAP occurred in 55%, 25%, and 20% of patients in the HOB elevation to <30°, 30°, and 45°study arms, respectively. The frequency of VAP was significantly lower in the 45° compared with the <30° study arm (P = .022); there were no significant differences between the <30° and 30° as well as the 45° and 30° study groups. Unlike the frequency of VAP, the timing of the VAP (early or late) was not dependent on the degree of HOB elevation (P = .703).

Conclusions: Keeping the mechanically ventilated patients in a semirecumbent position as close to 45°as possible should be the goal to prevent the development of VAP. The backrest elevation <30° should be avoided unless medically indicated.

Relevance to clinical practice: The study results reaffirm the crucial role of patient positioning, an essential nursing care intervention, in preventing VAP. Intensive care nurses can contribute to improving the VAP rates and outcomes by placing and keeping the patients in the correct position.

KEYWORDS
head of bed elevation, intensive care unit, mechanical ventilation, nursing care, ventilator associated pneumonia

1 | INTRODUCTION

Mechanical ventilation (MV) is a therapeutic intervention that supports or replaces spontaneous breathing and thereby supports adequate oxygenation of body tissues.[1] Ventilator-associated pneumonia (VAP), defined as infection of the lung parenchyma that occurs in patients who have been on MV for >48 hours (not incubating at the time of endotracheal intubation),[2] is one of the most common complications of invasive MV.[3]

Prevention of VAP is a priority for the effective management of mechanically ventilated patients because VAP is associated with prolonged MV, intensive care unit (ICU) stay, and hospitalization as well as increased healthcare costs and mortality.[2,4] Several interventions have been suggested to achieve this goal, in addition to the standard infection prevention and control measures. These mainly include non-invasive positive pressure ventilation, daily weaning from MV, avoiding re-intubation, minimization of sedation, daily sedation holidays, early mobilization, regular control of endotracheal tube cuff pressure, aspiration of subglottic secretions (use of endotracheal tubes with integrated suction lines if MV is required for >48–72 hours), avoiding normal saline instillation prior to endotracheal suctioning, regular oral care with antiseptic rinse, avoiding change of ventilator circuits, and filters unless contaminated or malfunctioning, verifying the position of the feeding tube before each feeding, selective oropharyngeal, and digestive decontamination and maintenance of head of bed (HOB) elevation to 30° to 45°.[5,6]

Aspiration of the refluxed gastric content and oropharyngeal secretions colonized with potentially pathogenic microorganisms have an essential role in the development of VAP.[6,7] Supine body positioning contributes to the pathogenesis of VAP by interfering with the native protective mechanisms (eg. cough, mucociliary clearance) and facilitating pulmonary aspiration.[6]

The association between body positioning and occurrence of VAP initially received attention in the 1990s. Torres et al. found that supine positioning increased the pulmonary aspiration of radiolabelled enteric feeding material in mechanically ventilated patients compared with the semirecumbent (at 45°) position.[8] A multivariate analysis of risk factors of aspiration pneumonia in a surveillance cohort revealed that the head position <30° within the initial 24 hours of MV was independently associated with the development of VAP.[9] Drakulovic et al conducted the first randomized controlled study investigating the impact of semirecumbent positioning on preventing VAP. The authors reported that raising the head to 45° significantly reduced the occurrence of VAP as compared with supine positioning.[10] These findings paved the way for HOB elevation (30°-45°) to be recommended by numerous organizations as a preventive measure against VAP.[5,11-15] Furthermore, semirecumbent positioning (30°-45°) has been incorporated as an essential nursing strategy in care bundles for preventing VAP.[16-18]

Little published data are available on the effectiveness of semircumbent positioning on VAP outcomes. The most recent systematic review of the available randomized controlled studies showed that HOB elevation to 30° to 60° reduced the clinically suspected VAP (an absolute risk reduction of 25.7%) compared with supine (0°-10°) positioning. However, the analysis did not reveal an improvement in other outcomes including microbiologically proven VAP, length of ICU, hospital stay, and duration on MV.[19] Semirecumbent position (45°) did not differ from HOB elevation to 25° and 30° in terms of VAP reduction either.[19,20] The paucity and the heterogeneity of the studies investigating the impact of various degrees of HOB elevation, and their contradictory results in terms of VAP outcomes prevented making suggestions about the optimal degree of HOB elevation in patients on MV.[19] There is a clear need for further research to determine the safe, effective, and feasible level of HOB elevation which will contribute to improved nursing care practices and patient outcomes. However, the scientific interest in conducting investigations in this field has remained low in recent years.

What is known about this topic

- Head of bed elevation from 30° to 45° is an evidence-based strategy widely recommended by guidelines to prevent VAP.
- Implementation of HOB elevation protocols in nursing care practice has been shown to improve VAP rates in patients on MV.

What this paper adds

- This study confirmed the beneficial effects of semi-recumbency at 45° in reducing the development of VAP compared with HOB elevation to <30°.
- Achieving and maintaining a semirecumbent position at 45°should be a target for mechanically ventilated patients unless contraindicated.

2 | AIM

The aim of this study, therefore, was to assess the impact of the two guideline-recommended degrees of HOB elevation (30° and 45°) on VAP prevention in comparison with HOB elevation to <30°.

3 | METHODS

3.1 | Study design and setting

This single centre, prospective, randomized controlled trial using parallel groups of 3 arms were conducted between January and July 2019, in adult ICUs (6 units, 54 beds) in a state hospital in Northern Turkey where no VAP prevention protocol was in place.

The medical staff of the ICUs included three medical doctors specialized in anaesthesiology and reanimation and 60 nurses. The duration of nursing shifts was 12 to 16 hours and each nurse was assigned to ≤3 patients at any shift. Each bed in the ICUs had a built-in control panel

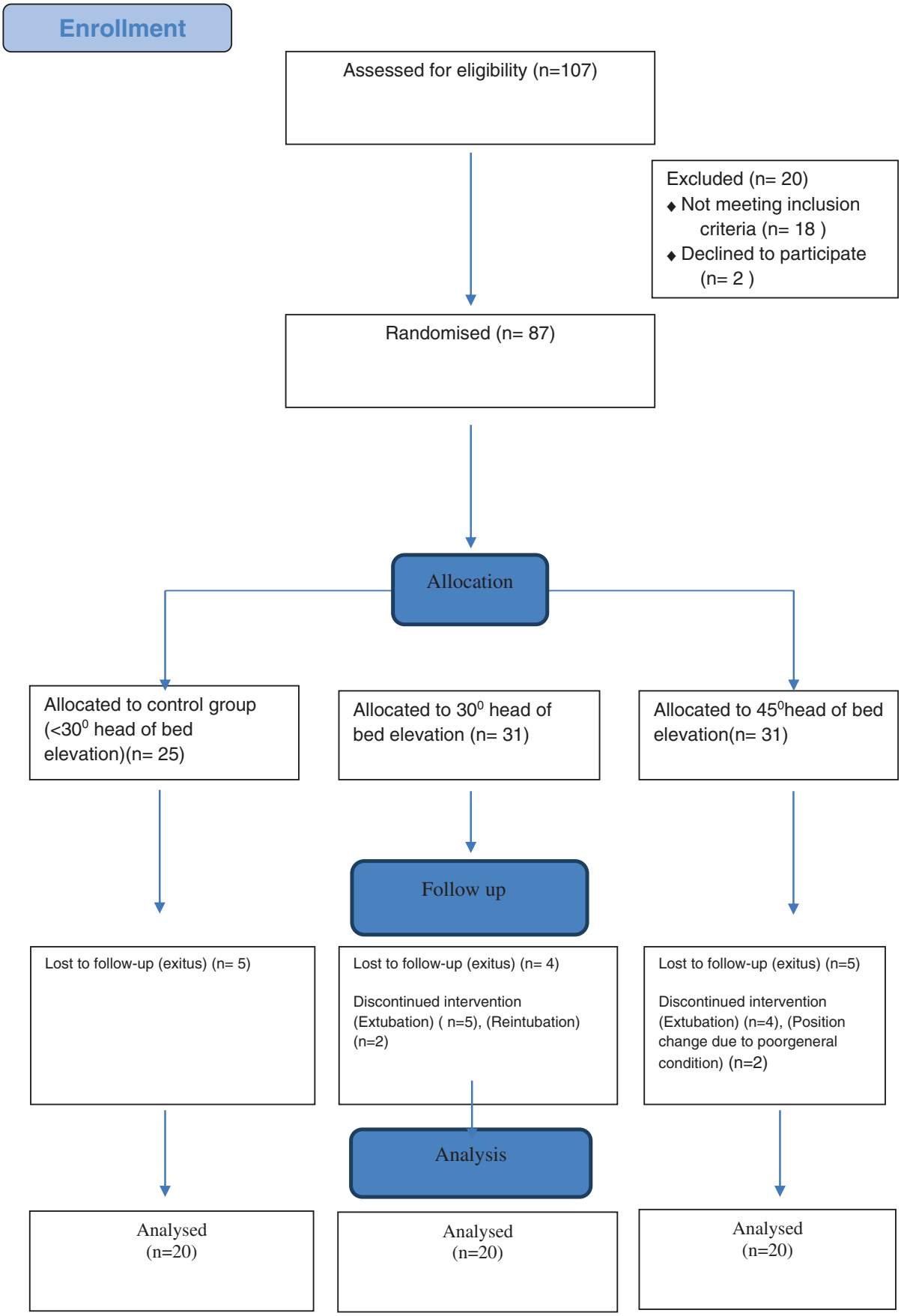

FIGURE 1 Patient allocation (the Consolidated Standards of Reporting Trials diagram)

allowing medical staff to easily adjust backrest (0°-65°) and legrest. There were specific markings for 30° and 45° backrest on the display. During backrest adjustment, the legrest angle was adjusted automatically (10°-20°) with 5 seconds delay to prevent pressure injuries.

3.2 | Study participants

Patients receiving mechanical ventilator support with orotracheal intubation in the ICUs were assessed for eligibility and those fulfilling the inclusion criteria were randomized in one of the study arms (30°, 45° and control [<30°] HOB elevation) and followed up for 5 days.

Patients were included in the study if they were ≥18 years of age, admitted to the ICU following orotracheal intubation either in the clinics or the ICU of the study hospital. Exclusion criteria consisted of history of endotracheal intubation in the previous 30 days, intubation in a different hospital before being admitted to the study site, hemodynamic instability (mean arterial pressure below 60 mm Hg for 30 minutes, resistant to colloid therapy or with inotropic support); obligatory supine position (following trauma or spinal surgery), post-abdominal surgery, or presence of surgical drains that might cause difficulty in patient positioning, diagnosis of VAP before admission to the ICU, obesity (body mass index [BMI] >30), and pregnancy. During the study, patients were withdrawn if they required a change of body position to improve ventilation or if they were transferred to another hospital, extubated, tracheostomized, decided to terminate their study participation or died.

TABLE 1 Procedures applied to all patients

Procedure	Application	Frequency
Body position	Elevation of head of bed to the assigned angle following transient, short-term changes to right/left lateral and supine positions	Every 2 h (for 5 min)
Body care	Elevation of the head to the assigned angle after performing the bed bath in the supine position	Once a day
Ventilation tubing		Not changed unless contaminated
Cuff pressure	Maintenance at 20 cm $H_2O$and regular checking and recording at every shift change	Four times a day (every 6 h)
Oral care	Use of an oral care kit with commercially available oral care solutions.	Four times a day (every 6 h)
Aspiration of subglottic secretions	Performed simultaneously with oral care	Four times a day (every 6 h)
Endotracheal aspiration (ETA)[a]	Using a sterile closed system aspiration system	As needed
Stress ulcer prophylaxis		As ordered by the physician
Vital signs	Continuous monitoring	Checked every hour

[a]Sample sent to microbiology lab for culture on day 1 and 5.

3.3 | Definitions

VAP was defined as a pneumonia which developed at least 48 hours after orophayngeal intubation (not incubating at the time of intubation) in line with the local diagnosis and treatment consensus report.[15] VAP that occurred within 96 hours of intubation was accepted as an early VAP.[21] The diagnosis of VAP was made by the physician based on the assessment of radiological (new or progressive infiltration, consolidation, effusion), laboratory (white blood cell counts, and microbiological confirmation of pathogenic organism in culture of endotracheal tube aspirate [ETA]) and clinical (physical examination, PaO_2/FiO_2 ratio, body temperature, change in the quantity, and purulence of the tracheobronchial secretions) findings. Clinical Pulmonary Infection Score criteria were used to assess the patients. However, the study required the microbiological confirmation of the pathogen in the ETA culture for the diagnosis of VAP.

3.4 | Sampling and randomization

The "G.Power-3.1.7" program was used for sample size calculation. The minimum number of patients for achieving a 95% confidence level, 0.8 effect size, and at least 80% statistical test power was 39 (13 patients in each arm).

Because male gender and old age are known risk factors for VAP development,[6] stratified sampling according to age (<65 vs ≥65 years of age) and gender was used and block randomization was performed to reduce any bias regarding patient allocation. The statistician (blinded) generated the allocation table. Homogeneity of the study arms was confirmed by chi-square test following randomization ($P > .05$).

Figure 1 provides the Consolidated Standards of Reporting Trials flow diagram of the study. A total of 107 patients were assessed for eligibility and 87 were randomized to the study arms. Analyses were conducted in 60 patients (20 patients in each group) who completed the 5-day study period.

3.5 | Study procedures

The principal investigator informed the physicians and nurses working in the ICUs about the study procedures in detail. The list of study procedures is provided in Table 1 .

TABLE 2 Patients' demographics and baseline clinical characteristics

Characteristics		Study arms			Test statistics	*P* value
		30° HOB elevation (N = 20) n (%)	45° HOB elevation (N = 20) n(%)	Control (<30° HOB elevation) (N = 20) n(%)		
Age	Mean ± SD	68.95 ± 21.09	77.35 ± 13.49	79.25 ± 11.27	3.465	.177*
Gender	Male	12 (60)	11 (55)	13 (65)	0.417	.812*
	Female	8 (40)	9 (45)	7 (35)		
Body mass index	Mean ± SD	22.7 ± 3.8	23.2 ± 4.09	23.45 ± 3.49	0.202	.818**
Reason for admission to ICU	Cardiac	6 (30)	6 (30)	7 (35)	0.582	.965***
	Neurological	9 (45)	8 (40)	9 (45)		
	Other [a,b,c]	5 (25)	6 (30)	4 (20)		
Chronic respiratory diseases	Yes	5 (25)	1 (5)	6 (30)	5.180	.075****
	No	15 (75)	19 (95)	14 (70)		
Hospitalization status before admission to ICU	Yes	3 (15)	5 (25)	4 (20)	0.630	.730****
	No	17 (85)	15 (75)	16 (80)		
APACHE II (day 1)	Mean ± SD	21.0 ± 6.1	22.2 ± 7.4	23.4 ± 5.9	0.679	.511**
CPIS (day 1)	Mean ± SD	1.4 ± 1.8	1.4 ± 1.8	2.5 ± 2.2	3.293	.193*

Abbreviations: APACHE, acute physiology and chronic health evaluation; CPIS, clinical pulmonary infection score; HOB, head of bed; ICU, intensive care unit.
[a]Gastrointestinal condition.
[b]Renal condition.
[c]Poor general condition.
*Kruskall-Wallis variance analysis.
**One-way analysis of variance (ANOVA).
***Chi-square analysis (Pearson Chi-square test).
****Chi-square Analysis (likelihood ratio test).

Following randomization, the patients in the control group (<30°) were left in the position they were initially placed by the ICU nurse, which was within the range of 15° to 20° HOB elevation. This was consistent with the observations that the investigator made during the 3 weeks' preparation period prior to the onset of the study. Patients in the 30° and 45° study groups were randomly placed in the assigned positions using the buttons on the adjustment panel. A warning sign and a note indicating the degree of HOB elevation were placed under the bedside monitor and on the room doors of the patients in the 30° and 45°study arms on the day of randomization. They were maintained there until the patient completed the study. Patients' positions were checked by the investigator and the intensive care nurse during the day shift, and by the senior nurse at the night shift. Patients' HOB positions were recorded in the nursing notes four times a day. No pillows were used to avoid any impact on HOB angle. The HOB elevation was maintained at the assigned degree for 5 days. Patients were repositioned (left/right lateral and on the back) every 2 hours and each repositioning took 5 minutes. The maximum duration allowed for placing the patients supine was 2 hours/day including repositioning, transport, and procedures.

The physicians clinically examined the patients, and evaluated the radiographic and laboratory findings regarding signs and symptoms of infection on a daily basis. The diagnosis of VAP was made by the physician based on the combined assessments of these findings. The data collection form and the clinical pulmonary infection score (CPIS) form were filled in by the researcher and daily changes were recorded.

At the end of the 5-day study period, an ETA was collected using a sterile closed tracheal aspiration system and sent to the microbiology laboratory for culture.

3.6 | Data collection

Socio-demographic and clinical characteristics were recorded on the Data Collection Form on the day of inclusion in the study. The Acute Physiology and Chronic Health Evaluation (APACHE II) score and CPIS were calculated daily and recorded for five consecutive days starting with the day of inclusion. Nurses checked the HOB angles four times a day (with 6 hour intervals) and recorded them in the nurse notes. The principal investigator visited the study participants on a daily basis, to check the correctness of HOB angles and reviewed the nurse records.

3.7 | Data collection form

The form consisted of a total of 13 items including age, gender, BMI, marital status, chronic diseases, date of hospitalization and intensive care admission, reasons for hospitalization, hospitalization status before admission to ICU, Glasgow coma scale score, Apache II score, history of intubation, and current medical treatment.

TABLE 3 APACHE II Score and CPIS of patients

Groups APACHE II score observation	Day 1 Mean ± SD	Day 2 Mean ± SD	Day 3 Mean ± SD	Day 4 Mean ± SD	Day 5 Mean ± SD	Test statistics	In-group *P*
30° head of bed elevation (N = 20)	21 ± 6.1	21 ± 6.1	21 ± 6.1	21 ± 6.1	22.2 ± 6.1	0.000*	.099
45° head of bed elevation (N = 20)	22.2 ± 7.4	21 ± 7.4	22.2 ± 7.4	22.2 ± 7.4	23.4 ± 7.4	0.000*	.099
<30° head of bed elevation (control) (N = 20)	23.4 ± 5.9	22.2 ± 5.9	23.4 ± 5.9	23.4 ± 5.9	22.2 ± 5.9	0.000*	.099
Intergroup *P*	.511	.511	.511	.511	.511		
Test statistics	0.679**	0.679**	0.679**	0.679**	0.679**		

Groups CPIS observation	Day 1 Mean ± SD	Day 2 Mean ± SD	Day 3 Mean ± SD	Day 4 Mean ± SD	Day 5 Mean ± SD	Test statistics	Inter-day differences	In-group *P*
30° head of bed elevation (N = 20)	1.4 ± 1.8	1.4 ± 1.8	1.5 ± 1.9	1.5 ± 1.9	2.0 ± 2.6	17.000**	1–5, 2–5	.002
45° head of bed elevation (N = 20)	1.4 ± 1.8	1.5 ± 1.8	1.5 ± 1.7	1.8 ± 1.8	2.0 ± 2.2	20.634**	1–5, 2–5	.0001
<30° head of bed elevation (control) (N = 20)	2.5 ± 2.2	2.6 ± 2.3	2.7 ± 2.3	2.9 ± 2.4	3.8 ± 3.1	29.209**	1–5, 2–5	.0001
Intergroup *P*	.193	.191	.151	.131	.139			
Test statistics	3.293***	3.309***	3.789***	4.059***	3.962***			

Abbreviations: APACHE, acute physiology and chronic health evaluation; CPIS, clinical pulmonary infection score.

*Friedman test.

**One way analysis of variance (ANOVA).

***Kruskal-Wallis variance analysis.

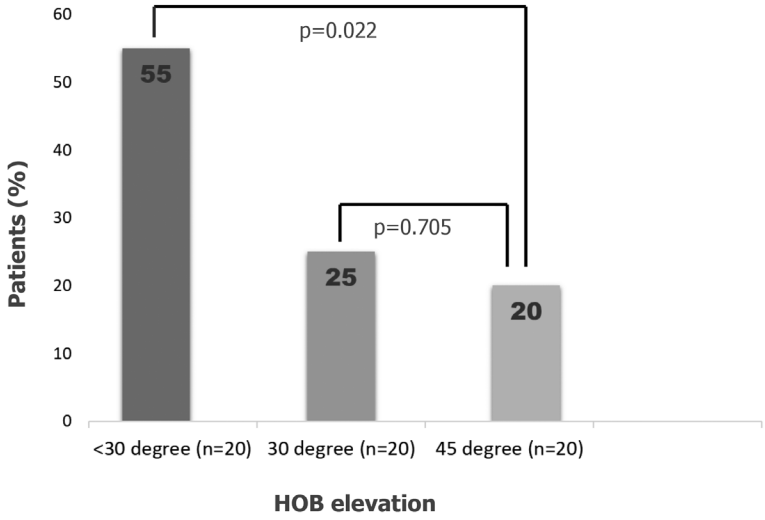

FIGURE 2 Patients with positive endotracheal aspirate cultures

3.8 | Acute physiology and chronic health evaluation score II

APACHE II is a prognostic scoring system predicting mortality in patients newly admitted to an ICU.[22] The model utilizes the worst values of 12 physiological variables during the first 24 hours following admission to ICU. The score consists of three components: physiological variables (body temperature, mean arterial pressure, heart rate, respiratory rate, oxygenation, arterial pH, venous HCO_3, sodium, potassium, serum creatinine, hematocrit, leukocyte, and Glasgow coma score), age, and chronic health status. The score ranges between 0 and 71; higher scores indicate increased mortality risk. High APACHE II score is a risk factor for VAP.

3.9 | Clinical pulmonary infection score

CPIS is a supportive tool for VAP diagnosis which considers the clinical, radiological, and microbiological findings.[23] It consists of seven parameters including body temperature, leukocyte count and morphology, tracheal secretion amount and character, PaO_2/FiO_2 ratio, presence of pulmonary infiltration, and its progression and microbiological culture results. The score ranges between 0 and 12 points. In this study, CPIS score was calculated daily to support physicians' assessment. A score of 6 or above is suggestive of VAP.

3.10 | Data analysis

The Statistical Package for Social Sciences Windows version 24.0 (IBM Corp., Armonk, NY) was used to analyse the data obtained from the study. Individual characteristics, chronic diseases, date of intensive care admission, reason for hospitalization, hospitalization status before intensive care admission, and questions regarding current medical treatment were expressed using numbers and percentages, while BMI, CPIS, and Apache II score were expressed using mean, ±SD, minimum, and maximum values. The Shapiro–Wilk test was used for testing distribution normality. In the analysis of numerical data, one-way analysis of variance and Kruskal Wallis variance analysis were used to compare independent group differences in case of normal and non-normal distribution, respectively. Friedman test was used for the assessment of dependent variables. Chi-square analysis was used for examining categorical variables across groups. The value of 0.05 was considered significant in all analyses.

3.11 | Ethical considerations

The study protocol was approved by the Ethics Committee of the Karabük University Medical Faculty. Written approval was obtained from the Local Health Authority for the conduct of the study.

The purpose, method, and voluntary basis of the research were explained to the patients or their first-degree relatives (in case patients were sedated or unconscious) by the researcher, verbally and in writing, to ensure voluntary participation and their written consents were obtained.

4 | RESULTS

Sixty of the 87 randomized patients (20 patients in each arm) completed the 5-day study period (Figure 1). Socio-demographics and baseline clinical characteristics of patients were comparable across the study arms (Table 2).

No statistically significant differences were observed between the study groups in terms of baseline APACHE II scores (F = 0.679; P = .511) and CPIS (H = 3.293; P = .193). The scores were also comparable across the study groups throughout the study. In-group evaluation of the CPIS pointed out that the scores on the first and second day were significantly lower than those of the fifth day in all study arms (P < .05). (Table 3).

VAP occurred in 33% of the patients (20/60) over 5 days. All cases were microbiologically confirmed by the ETA culture. The growth of pathogens in the culture was dependent on the degree of HOB elevation (χ^2 = 6.45; *P* = .041). The percentages of patients with positive cultures in each study arm are shown in Figure 2 . More patients in the <30° group had VAP than in the 45° group (55% vs 20%; χ^2 = 5.227, *P* = .022). The difference between the 30° and 45°study arms was not significant (25% vs 20%; χ^2 = 0.143, *P* = .705). Similarly, the 30° and <30° study groups did not differ significantly in terms of VAP occurrence (25% vs 55%; χ^2 = 3.75, *P* = .053).

The timing of the VAP was not dependent on the degree of HOB elevation (likelihood ratio = 0.704; *P* = .703). Late VAPs constituted 85% of all VAP cases. The microorganisms isolated in the early VAP cases were: multipleGram (+) bacteria (n = 1), *Candida albicans* (n = 1) and *Staphylococcus epidermidis* (n = 1), whereas Acinetobacter baumanii (n = 8), *Klebsiella pneumoniae* (n = 8), and *Pseudomonas aeruginosa* (n = 1) were detected in patients with late VAP.

5 | DISCUSSION

This study evaluated the impact of the two guideline-recommended degrees of HOB elevation (30° and 45°) on the development of VAP compared with the control group (HOB elevation to <30°) in adult mechanically ventilated patients. All VAP cases were microbiologically confirmed by the ETA culture. The HOB elevation to 45° was the only arm that resulted in significantly lower VAP occurrence compared with the control (HOB elevation to <30°) group (*P* = .022). The incidence of VAP in semirecumbent position at 30° was lower by 30% than in the control group. Although the difference between the two groups was not statistically significant (*P* = .053), it may still be clinically meaningful.

In the literature, there are few studies that investigated the comparative effectiveness of HOB elevation to 30° and 45° in terms of VAP development. To our knowledge, there is only one 3 arm study apart from the current study that investigated the impact of HOB elevation on VAP development.[22] Ghezeljeh et al[24] investigated the impact of HOB elevation to 30°, 45°, and <30° and reported that HOB elevation to 45° resulted in a significantly lower incidence of VAP compared with <30°, as in the present study. Although there were no significant differences between the 30° and 45° study arms in terms of the percentage of patients developing VAP, the results were in favour of the 45° semirecumbent position in both studies. Similarly, the differences between the 30° and <30° arms were not significant regarding the occurrence of VAP in the studies, but the frequencies of VAP in the 30° arms of both studies were numerically lower than in the <30° arms. It is noteworthy that there are several differences across the studies which might have affected the results. In the study by Ghezeljeh et al,[24] the diagnosis of VAP was based on a CPIS score greater than 6 in contrast to our study in which all VAP cases were microbiologically confirmed. The patients in our study were older than the ones in the study by Ghezeljeh et al.[24] Because old age is a risk factor for VAP development,[6] it might have had a negative impact on the VAP frequencies in the present study. Patients were followed up for 5 days in the current study, whereas the follow-up duration was 3 days in the study by Ghezeljeh et al.[24] It was previously reported that the risk of VAP was greatest within the initial 5 days and the mean duration for the development of VAP was 3.3 days.[25] Additionally, the patient population was more heterogenous (included cancer and trauma patients) and the baseline APACHE II scores were higher and not uniformly distributed across the trial groups in the study by Ghezeljeh et al[24] in contrast to our study. All these factors make it difficult to compare the results of these two studies.

Confounding factors were also present in the other previously published studies investigating the impact of HOB elevation on the prevention of VAP.[19] The heterogeneity of the studies and the patient populations were previously mentioned by Wang et al who emphasized a need for a cautious assessment of the results of their systematic review of 10 randomized controlled studies evaluating the impact of HOB elevation on VAP development.[19] Hence, one should consider the variations in terms of patients' demographics and clinical characteristics such as gender, age, underlying disorders, reason for MV, and concomitant drug use while comparing findings from various studies. The study designs, settings, and outcomes (eg. study durations, implementation of bundles for preventing VAP, monitoring HOB elevation, outcomes of interest such as mortality, duration of hospitalization, onset of VAP, etc.) also differ to a great extent.

According to the review by Wang et al., the semirecumbent position at 30° to 60° reduced the clinically suspected VAP but not the microbiologically confirmed ones versus supine (0°-10°) positioning.[19] Microbiologically confirmed VAP was an outcome in only four studies (two studies compared HOB elevation to 45° versus supine; one study compared 45° and 25° and one study compared 30°-60° versus supine).[19] Among these studies, Drakulovic et al's was the only study that showed a reduction in microbiologically confirmed VAP; the clinically suspected VAP also decreased in this study.[10] The study by Keeley et al which compared the impact of 45° and 25° HOB elevation did not reveal any difference between the study groups regarding the microbiologically confirmed and the clinically suspected VAP.[20] An interesting finding from the study by Van Nieuwenhoven et al. was that the target level of HOB elevation (45°) was achieved and maintained in less than 85% of study duration. The average angles that were achieved were around 28° and 23° on first and seventh day, respectively. The level of HOB elevation achieved failed to prevent VAP.[26] Despite being inconclusive regarding VAP outcomes, the study is valuable because it has attracted attention to an important issue that can be frequently faced while conducting studies. Indeed, we did not continuously measure the angles in the present study, therefore, we could not document the exact degrees the patients reached and for how long they were kept in the targeted positions. This issue is also important in terms of daily nursing practice. Based on the findings from a multicentre, observational study, Rose et al. reported that the recommended HOB elevation level (30°-45°) was not achieved in a substantial group of patients even in the absence of contraindications.[27]

Another point that should be mentioned at this point is the concern that elevating the HOB to greater than 30° results in greater shear and friction and may thereby contribute to increased pressure injuries. Keeping the patients as flat as possible (elevating the HOB to ≤30°) is recommended to avoid pressure injuries[28] conflicting with recommendations for preventing VAPs.[5,11-15] Assessment of the impact of the angle of HOB on development of pressure injuries was not among the objectives of this study and we did not examine any factors associated with pressure injuries. In a two-day study, Schallom et al randomly positioned 15 mechanically ventilated patients to 30° or 45° HOB elevation for 12 hours and crossed-over following a 12 hours wash-out period. The investigators reported that elevating the HOB to >30° was superior to reduce the risk of aspiration and patients could be maintained without pressure ulcer development with regular repositioning of patients and use of low air loss mattresses.[29] We recognize the importance of the issue and acknowledge that it deserves assessment in further studies with larger sample sizes. Identifying patients at risk for pressure ulcer development,[30] examining the skin over pressure points regularly and carefully for any alterations are critical in clinical practice and should be considered to properly position the patients.[28]

Because critically ill patients are at an increased risk of gastrointestinal bleeding, stress ulcer prophylaxis (SUP) was given to all patients as part of the routine ICU protocol. Proton pump inhibitors were used for this purpose. SUP raises the gastric pH and thereby facilitates bacterial overgrowth in the stomach. This in turn facilitates the tracheobronchial colonization and VAP development. A recent Cochrane analysis reported that there were no significant differences between sucralfate, proton pump inhibitors, and H2 receptor antagonists in terms of VAP development. However, the quality of data are low to moderate and it was reported that a risk–benefit assessment should be made on an individual basis.[31]

Sedatives are known to contribute to the development of VAP by impairing the cough reflex and the mucociliary clearance. They were given as a continuous intravenous infusion to all conscious patients who required invasive mechanical ventilatory support to diminish their anxiety, agitation, and discomfort associated with the MV, irrespective of their participation in the study. Daily sedation interruption has been shown to significantly decrease the incidence of VAP rates as compared with the continuous sedation study arm.[32] Daily sedation interruption was not part of the ICU treatment protocol and was also not applied during this study.

In our study, the aetiological agents responsible for the development of early and late VAPs consisted of antibiotic-sensitive and multidrug-resistant pathogens, respectively. Although the observed pathogens were consistent with those reported in the literature, one should remember that the causative agents may vary depending on the microbial flora of the ICU and clinical characteristics of the patients.[21]

6 | STRENGTHS AND LIMITATIONS

To our knowledge, there has been only one randomized controlled study published previously investigating the impact of HOB elevation to 30°, 45°, and <30° in parallel allowing a direct comparison of effectiveness of patient positioning on the development of VAP.[11] Therefore, the results of the present study are valuable in terms of providing additional comparative effectiveness data. The other major strength of this investigation is the randomized controlled study design with a stratified sampling and a block randomization ensuring the homogeneity of the study groups at baseline and preventing any selection bias.

Several limitations to the current study need to be acknowledged. First, the sample size of the study was small. However, the adequate number of patients calculated to achieve the targeted statistical significance (13 in each arm) was reached. Secondly, the study was conducted in a single centre; therefore, the study results may not represent other hospital settings. Thirdly, continuous monitoring of the HOB elevation was not available; therefore, we could not document the exact duration that each patient spent in the assigned position or calculate the mean values. Nevertheless, every effort was made to ensure adherence to the assigned HOB elevation. The built-in control panel which had specific markings for 30°and 45° HOB elevations allowed a fine adjustment. The staff were informed about the maximum period (2 hours/day) allowed for position change. A warning sign and a note indicating the degree of HOB elevation was placed under the bed side monitor and on the patient room door to avoid any change in patient position.

7 | NURSING IMPLICATIONS

Although there are many risk factors associated with the development of VAP, it is strongly evident that effective nursing practice reduces the frequency of VAP. Keeping the HOB at 45° is a no-cost, non-pharmacological intervention that nurses can independently implement to reduce the risk of VAP in almost any clinical setting. The role of the intensive care nurse is crucial in preventing the occurrence of VAP, a device-associated complication of invasive MV. Fulfilment of nursing responsibilities to mechanically ventilated patients will improve the quality of healthcare, shorten the duration on MV, and prevent the development of VAP.

8 | CONCLUSION

This study reinforced the importance of implementing HOB elevation in the management of patients on MV. Our results confirm the beneficial effects of HOB elevation to 45° which is a no-cost, simple, evidence-based VAP prevention strategy. In the light of the currently available data, placing and keeping the mechanically ventilated patients in semirecumbent position as close to 45° as possible should be the goal and HOB elevations below 30° should be avoided unless medically contraindicated. Considering the paucity of the data and the presence of confounding factors, it is clear that there is a need for further studies with larger sample sizes and longer duration investigating the comparative effectiveness and safety of various levels of HOB elevation to reveal the optimal, safe, and

effective degree of semirecumbent positioning for well-defined patient populations.

AUTHOR CONTRIBUTIONS

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