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Evaluation of ventilator-associated pneumonia care practice in the intensive care units of a comprehensive specialized hospital in Northwest Ethiopia: a 1.5-year prospective observational study

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Abstract

Background Nosocomial infections pose a global health threat, with Ventilator-Associated Pneumonia (VAP) emerging as a prominent hospital-acquired infection, particularly in intensive care units (ICU).VAP is the commonest form of pneumonia in ICUs, contributing significantly to morbidity and mortality rates, which can reach around 30%. Despite the substantial impact of VAP on healthcare, there is a lack of data on adherence to VAP prevention protocols in our hospital. Consequently, this study aims to assess the adherence to ventilator-associated pneumonia care bundles in critical care units at a comprehensive specialized hospital in northwest Ethiopia.

Methods A hospital-based prospective observational study was conducted from July 3, 2022, to January 7, 2024. All adult patients who were on mechanical ventilators for more than 48 h during the study period were included. Data were collected using the Institute of Healthcare Improvement VAP prevention standards as checklists via direct observation and chart review. The data were entered and analyzed using SPSS version 20.

Results A total of 300 surgical and medical ICU patients were observed. Among the patients, 66.3% were from the medical ICU. In terms of admission reasons, 22.3%, 15.7% and, 12% were attributed to infections excluding respiratory origin, respiratory disorders, and other causes, respectively. The rate of compliance with all components of the bundle was 70%. A 100% adherence rate was observed for the prophylaxis for peptic ulcer and deep vein thrombosis (DVT). The lowest adherence rate was observed in the practice of oral hygiene with 0.5% chlorhexidine solution (0%) followed by humidification with heat and moisture exchangers (23.3%). Endotracheal tube cuff pressure measurement and use of endotracheal tubes with subglottic suction were not applicable.

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Conclusion The study revealed suboptimal compliance with the VAP care bundle, indicating unsatisfactory overall practice. Specific attention is warranted for subglottic suction, cuff pressure measurement, humidification, oral care with chlorhexidine, and sedation vacation.

Keywords Pneumonia, Ventilator, Care bundles, Intensive care unit, Nosocomial infection

Introduction

Critically ill patients are vulnerable to hospital-acquired infections due to their illness, the use of multiple invasive devices, antibiotic treatments, and the pathogenic nature of the intensive care setting [1]. Tracheal intubation and invasive mechanical ventilation are life-saving interventions for a large number of critically ill patients in ICUs. Despite their benefits, mechanical ventilation is associated with multiple complications, the most frequent being ventilator-associated pneumonia (VAP) [2].

Ventilator-associated pneumonia (VAP) is a parenchymal lung infection occurring in intubated patients supported with a mechanical ventilator for 48 h or longer, with no prior signs or symptoms of lower respiratory infection before intubation and mechanical ventilation [3]. VAP is among the most widespread health care-associated infections in the ICU and accounted for 50% of all health care-associated infections [4].

The International Nosocomial Infection Control Consortium (INICC) reported that the incidence of VAP is about 13.6 per 1000 mechanical ventilation days [5]. Worldwide, the prevalence of ventilator-associated pneumonia was 12.6%, 13.5% in the US, 19.4% in Europe, 13.8% in Latin America, and 16% in South Asia [6]. The incidence of VAP in Egypt was 22% [7]. A study done in Bahir Dar, Ethiopia, reported that the incidence of VAP was found to be 27.9 [8].

VAP is associated with a substantial morbidity and mortality rate of around 30%, contributing to prolonged hospital stays, heightened utilization of healthcare resources, increased medical expenses, and delayed extubation [1, 9, 10]. As a result, VAP prevention in the ICU is considered a crucial patient safety initiative and a key indicator of healthcare quality [11]. The Institute for Healthcare Improvement has introduced a guideline referred to as the VAP bundle, which consists of a detailed set of recommendations designed to prevent VAP [12]. Compliance with care bundles in clinical practice has been widely endorsed for patients on mechanical ventilators in the ICU and is associated with a decreased risk of VAP [13].

Nursing care plays a crucial role in preventing VAP and improving outcomes for ICU patients. Higher nursing compliance and the implementation of a VAP bundle in the care of patients on mechanical ventilators have been shown to reduce VAP occurrences, resulting in fewer ventilator days, shorter ICU and hospital stays, and lower mortality and morbidity rates [14]. Nonetheless, the extent to which nurses follow this guideline is still unclear in developing countries [15]. Limited knowledge may pose a barrier to implementing and following these guidelines. A multi-center study in northwest Amhara revealed that ICU nurses' knowledge of VAP prevention is inadequate [16].

Although the use of VAP bundles in clinical practice is observed, non-adherence behavior still exists [17]. Despite its considerable burden on healthcare settings, data regarding the adherence to the recommended protocol in our hospital is lacking. Thus, this study was aimed at evaluating the adherence to VAP care bundles in critical care units at the University of Gondar Comprehensive Specialized Hospital in northwest Ethiopia.

Methods and materials

Study design, setting and period

This single-center prospective observational study was conducted from July 3, 2022, to January 7, 2024, at the University of Gondar Comprehensive Specialized Hospital in northwest Ethiopia. Our comprehensive specialized hospital has two ICU settings, medical and surgical ICU. Surgical ICU has eight beds and six mechanical ventilators, whereas medical ICU has ten beds and five mechanical ventilators. During the study period, 319 patients were admitted to the ICU and were on mechanical ventilators. Of these, 19 critically ill patients were excluded from the study due to death or weaning from the mechanical ventilator before 72 h.

Inclusion and exclusion criteria

Adult patients who were admitted to both the medical and surgical ICUs and had undergone intubation and ventilation for an anticipated duration of more than 48 h were included, whereas patients who died, were extubated before day three, and whose attendant refused to give consent were excluded from the study. The study follows the Enhancing the Quality and Transparency of Health Research (EQUATOR) guideline, Strengthening the Reports of Observational Studies in Epidemiology (STROBE) [18].

Variables of the study

Compliance The VAP prevention practice is considered compliant when it was provided according to the protocol, whereas a practice that is not performed as per the protocol is considered non-compliant.

Compliance rate The ratio of the number of patients who received the standard VAP prevention care to the whole patients who were on mechanical ventilators.

Non-applicable The VAP prevention bundle was deemed non-applicable when it was not practiced owing to reasons unrelated to the health care providers, such as a lack of medical equipment or monitors essential to provide that specific clinical practice.

Data collection instrument

The institute for healthcare improvement has developed standards for the prevention of ventilator-associated pneumonia. Specific exclusion criteria for each protocol's parameter were clearly mentioned (Table 1). Data were collected using Institute of Healthcare Improvement standard checklists and directly changed into question forms, Yes, No, and not applicable. The expected compliance rate for all ventilator-associated pneumonia prevention care bundles is advised to be 100% [2, 10].

Data collection procedure

Data were collected using the Institute of Healthcare Improvement for VAP prevention protocols as a checklist via direct observation and chart review. Training was provided for two senior anesthetists to collect the data. Medical records of patients on mechanical ventilators for an anticipated length of more than 48 h were reviewed, and patients were directly observed three times per day for 3 days.

Sampling technique

Patients on mechanical ventilators were included in the study using a consecutive sampling technique.

Sample size determination

During the study period, 319 critically ill patients were admitted to the ICU and were on mechanical ventilators. All these patients were included and were the sample size of this study.

Data processing and analysis

The collected data were checked for completeness, accuracy, and clarity. SPSS version 20 was used for data entry and analysis. Frequency and percentage distribution of data were computed. Results were narrated in text and reported via table and figure formats.

Ethical consideration

Ethical clearance was obtained from the ethical review board of the school of medicine, University of Gondar. An informed written consent was taken from attendants or family members.

Results

Socio-demographic clinical characteristics of patients

The majority of individuals in the study, accounting for 58.3%, were male patients. Approximately 39.7% of the participants fell within the 18–40 age range. Among the patients, 66.3% were from the medical ICU. In terms of admission reasons, 22.3% were attributed to infections excluding chest foci, while the smallest proportion (12%) was due to other causes (Table 2).

Compliance rate to VAP care bundles

The analysis of compliance with the VAP care bundle involved 300 patients admitted to both medical and surgical Intensive Care Units and placed on mechanical ventilators. Remarkably, adherence rates to four of the VAP care bundles were promising. Specifically, the head of the bed was elevated for 98.3% of patients. A perfect

Table 1 The institute for healthcare improvement standards for prevention of ventilator-associated pneumonia

S. *N*	Standards	Expected Compliance (%)	Exclusion criteria
1	Intubated patients should be positioned in semi-recombinant position ($30–45^0$) for as much of the time as possible	100%	spine injury
2	Maintenance of adequate endotracheal tube cuff pressure between 20–25 cmH_2O	100%	none
3	Oral hygiene with 0.5% Chlorhexidine solution eight hourly	100%	oropharyngeal trauma, allergy to chlorhexidine
4	Sedation must be reviewed and daily sedation vacation and readiness to wean and extubation has to be assessed	100%	difficult ventilatlation, refractory hypoxia, high ICP
5	Peptic ulcer prophylaxis	100%	none
6	Deep vein thrombosis (DVT) prophylaxis	100%	none
7	Using Endo tracheal tubes with subglottic suction	100%	none
8	Humidification with heat and moisture exchangers	100%	none
9	Scheduled drainage of condensate from ventilator circuits	100%	none

ICP: Intracranial pressure

Table 2 Socio-demographic and clinical characteristics of ICU patients on mechanical ventilators (*N* = 300)

Variable	Category	Frequency (*n*)	Percentage (%)
Age	18–40	119	39.7
	41–65	103	34.3
	> 65	78	26
Sex	Female	125	41.7
	Male	175	58.3
ICU setting	Medical	199	66.3
	Surgical	101	33.7
Causes of admission	Respiratory disorder	47	15.7
	Cardiovascular disorder	49	16.3
	Infection	67	22.3
	Trauma	53	17.7
	Surgical (post-operative)	48	16
	Others	36	12

Others: CNS disorders including GBS and MG, Burn, GI disorders, endocrine disorders

adherence rate of 100% was observed in providing prophylaxis for peptic ulcers and deep vein thrombosis. Scheduled drainage of condensate from ventilator circuits was demonstrated in 96.7% of patients (Table 3).

Conversely, oral hygiene practices using a 0.5% chlorhexidine solution had a 0% compliance rate in both the medical and surgical ICU settings (Table 3). Notably, certain practices, such as maintaining endotracheal tube cuff pressure within the specified range of 20–25 cmH_2O and utilizing endotracheal tubes with subglottic suction, were deemed non-applicable (Table 3).

The overall compliance rate to the VAP care bundles in our ICU was 70% (Fig. 1). Our finding revealed that there was an improvement in the practice of VAP prevention for ICU patients on mechanical ventilators in each separated six months over 1.5 years (Fig. 2).

Discussion

Evidence-based therapies for mechanically ventilated patients can reduce morbidity, mortality, and costs of care [19]. Implementation of VAP care bundles reduces the rate of occurrence of VAP in ICU even with compliance rates as low as 30% [13]. Despite evidence that specific intervention can reduce morbidity and mortality for mechanically ventilated patients, there is a gap between best evidence and practice. This clinical audit evaluated the use of the VAP bundle in the adult ICU settings at the University of Gondar Comprehensive Specialized Hospital in northwest Ethiopia.

The evaluation of compliance of ICU care for patients on mechanical ventilators to each VAP bundle is critical. DVT and peptic ulcer prophylaxis were the most adhered elements to the VAP bundle of care, which was similar to the study done in Australia in 2020 [20]. Nonetheless, it is widely agreed that critically sick or mechanically ventilated patients are at a high risk of DVT and should be given thromboprophylaxis. In severely ill patients, thromboprophylaxis is effective at preventing DVT [19]. In mechanically ventilated patients, PUD prophylaxis lowers the incidence of upper gastrointestinal hemorrhage. Patients who are mechanically ventilated are more likely to experience upper GI bleeding, and the evidence suggests that prophylaxis should be considered [19].

In this study, the practice of sedation review and daily sedation vacation and readiness to wean and extubation was suboptimal, and this finding was consistent with a similar study conducted in India [21]. Daily interruption of sedative drug infusions decreases the duration of mechanical ventilation and length of stay in the ICU [19]. The findings of a study in Iran indicated that in patients with intravenous sedation, infusion of a daily sedation vacation protocol reduces the incidence of VAP. Therefore, in order to prevent VAP, nurses are advised to apply the daily sedation vacation protocol [22].

Furthermore, according to a study done in Australia, the compliance rate of head of bed elevation was promising and is consistent with our study finding [20]. Keeping the mechanically ventilated patients in a semi-recumbent position as close to 45° as possible should be the goal to prevent the development of VAP. The backrest elevation less than 30° should be avoided unless medically indicated [23].

Table 3 Frequency distribution of *compliance to VAP* care bundle in ICU (*N* = 300)

Standards	Yes (*n*, %)	No (*n*, %)	Not Applicable
1. Intubated patients positioned in semi-recombinant position (30–45^0)	295 (98.3)	5 (1.7)	0 (0)
2. Endotracheal tube cuff pressure maintained between 20–25 cmH_2O	0 (0)	0 (0)	300 (100)
3. Oral hygiene with 0.5% Chlorhexidine solution eight hourly used	0 (0)	300 (100)	0 (0)
4. Sedation reviewed and daily sedation vacation and readiness to wean and extubation were assessed	215 (71.7)	85 (28.3)	0 (0)
5. Peptic ulcer prophylaxis given	300 (100)	0 (0)	0 (0)
6. Deep vein thrombosis (DVT) prophylaxis given	300 (100)	0 (0)	0 (0)
7. Endotracheal tubes with subglottic suction used	0(0)	0 (0)	300 (100)
8. Humidification with heat and moisture exchangers applied	70 (23.3)	230 (76.7)	0 (0)
9. Scheduled drainage of condensate from ventilator circuits performed	290 (96.7)	10 (3.3)	0 (0)

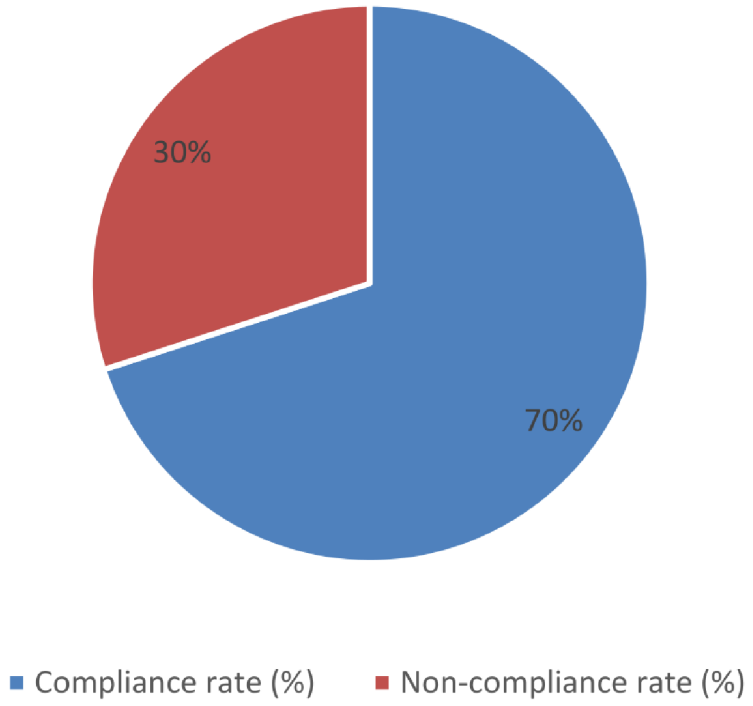

Fig. 1 Overall compliance rate to VAP care bundles in ICU

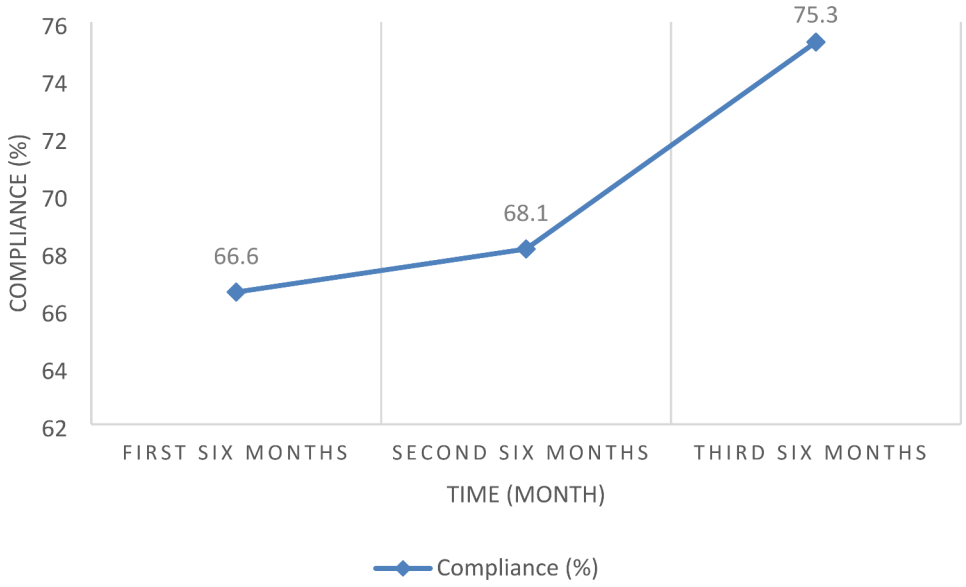

Fig. 2 Trend of Compliance to VAP care bundles in ICU over 1.5 years

According to a study in Egypt, ICU nurses did not maintain sufficient pressure in the endotracheal tube cuff, despite guidelines suggesting a minimum cuff pressure of 20 cmH_2O and the continuous aspiration of subglottic secretions [3]. This finding aligns with our results, as subglottic suction and maintaining endotracheal tube cuff pressure between 20 and 25 cmH_2O were not performed, primarily due to a lack of equipment. In the absence of equipment for measuring endotracheal cuff pressure, ICU nurses opted for the cuff palpation method to maintain cuff pressure. However, this practice introduces the risk of either over-inflation, potentially leading to issues like sore throat, tracheoesophageal fistula, and tracheal stenosis, or under-inflation of the tracheal cuff,

which could contribute to the development of ventilator-associated pneumonia [24].

In addition, in both ICU settings, the practice of oral care with chlorhexidine was similar to a finding reported in Sri Lanka [10]. These might be due to the availability of contradictory evidence on the use of chlorhexidine [25]. This non-adherent behavior is partly due to the fact that health care providers lack knowledge, as evidenced by a prior multi-center study conducted in the Amhara region of Ethiopia, which reported that nurses working at ICU had inadequate knowledge [16]. Adherence to drainage of fluid in the ventilator circuit in our study was satisfactory and higher (96.7%) than study done in Brazil (72.8%) [26]. This discrepancy may be attributed to the smaller number of patients in our setting than in Brazil.

The overall compliance to prevention of VAP bundles was 70%, which is suboptimal. This finding aligned with a prior study conducted in ICU nurses, revealing inadequate knowledge among those working in ICU. The absence of regular, continuous professional development programs appears to be a contributing factor to this identified substandard practice [16]. Moreover, it is well documented that suboptimal compliance rate may contribute to the high incidence of VAP rate as there is a negative correlation between ventilator bundle compliance and the VAP rate [11, 13, 27].

This finding was higher when compared to similar studies in Sri Lanka [10], Iran [28], Finland [29] and Brazil [30], with a compliance rate of 28%, 26.3%, 65.8%, and 66.7%, respectively. This could be due to variances in the number of study participants and duration of study periods. However, it was lower when compared to studies done in Australia (88.3%) [20] and in the kingdom of Saudi Arabia (85.9%) [2, 11]. This is explained in part by differences in study settings, with ours being resource-constrained.

Furthermore, the trend of VAP prevention practice in our setting has improved over 1.5 years. This relatively improvement in adherence rate over time is partly due to the routine case-based discussion of patient's conditions and care provision held in morning sessions since 2023 by senior anesthetists, internists, and nurses working in the ICU.

Limitation of the study

In this study, the focus was on evaluating the adherence to Ventilator-Associated Pneumonia (VAP) prevention care bundles in a comprehensive specialized hospital, aligning with established standards. The study identified significant gaps in the adherence rates to the VAP prevention care bundle. However, it did not identify the root causes of the observed issues or explore the impact on the incidence of VAP and its pathogen.

Conclusion and recommendation

The study revealed a suboptimal compliance rate to VAP care bundles, indicating unsatisfactory overall practice. Specific attention is warranted for endotracheal tubes with subglottic suction, endotracheal tube cuff pressure measurement, humidification with heat and moisture exchanger, oral care with chlorhexidine, and daily sedation review and vacation.

Discussion of findings with relevant intensive care units is recommended to raise awareness among physicians and critical care nurses. Ensuring the availability of equipment and adhering to guidelines is crucial. Frequent audit cycles and incorporating the VAP care bundle into daily nursing monitoring charts are suggested for improving reliability and encouraging evidence-based practices. Moreover, we also encourage future scholars to conduct a study to determine the prevalence of VAP and an interventional study and its impact on VAP rate and compliance with the existing protocols.

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S.A. Debas, B.A. Admass, W.B. Chekol, A.T. Mersha, D.Y.Melesse, M.M.Workie, B.M. Admassie and M.E.Zeleke were involved in the conception and design of the study, acquisition of the data, analysis and interpretation of data, drafting of the manuscript and approval of the final version of the manuscript.

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Data availability
The data sets used and analyzed during the study are available from the corresponding author on reasonable request.

Declarations

Human ethics and consent to participate
Ethical clearance was obtained from ethical review board of school of medicine with a reference number SOM 09/06/503/2022. An informed written consent from study participant's attendant or family member was taken.

Clinical trial number
Not applicable.

Consent for publication
Not applicable.

Conflict of interest
There is no conflict of interest among the authors of the article.

Competing interests
The authors declare no competing interests.

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