Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2023 Apr 02; 11(G):69-77.
https://doi.org/10.3889/oamjms.2023.11470
eISSN: 1857-9655
Category: *G - Nursing*
Section: *Nursing in Internal Medicine*

Ventilator-associated Pneumonia in the Intensive Care Unit of the Institute of Oncology Ljubljana in 2021 and the Role of Nurses in its Prevention

Sabina Medjedovic*, Tomaž Jurca, Milena Kerin Povšič

Institute of Oncology, Ljubljana, Slovenia

Edited by: Ksenija Bogoeva-Kostovska
Citation: Medjedović S, Jurca T, Povšič MK. Ventilator-associated Pneumonia in the Intensive Care Unit of the Institute of Oncology Ljubljana in 2021 and the Role of Nurses in its Prevention. Open Access Maced J Med Sci. 2023 Apr 02; 11(G):69-77. https://doi.org/10.3889/oamjms.2023.11470
Keywords: Ventilator-associated pneumonia; Incidence; Nursing care; Education; Nurses role
***Correspondence:** Sabina Medjedovic, Institute of Oncology, Ljubljana, Slovenia. E-mail: smedjedovic@onko-i.si
Received: 10-Jan-2023
Revised: 20-Mar-2023
Accepted: 23-Mar-2023

Funding: This research did not receive any financial support
Competing Interests: The authors have declared that no competing interests exist

Abstract

BACKGROUND: Ventilator-associated pneumonia (VAP) is the most common infection in critically ill patients and has the highest mortality. It prolongs ventilation time and length of stay, increases antibiotic consumption, increases the likelihood of death, increases the cost of treatment, and is difficult to diagnose.

AIM: At the intensive care unit (ICU) of the Institute of Oncology, Ljubljana, we prospectively monitor risk factors for VAP and its incidence. It is a mixed surgical/internal ICU.

METHODS: A centers of disease control and prevention VAP diagnosis criteria and strategies to prevent VAP were used. Registered nurses recorded risk factors in all intubated patients in all three shifts, and the diagnosis protocol was completed by the physician in case of antibiotic administration in suspected VAP.

RESULTS: The expected incidence of VAP is around 18/1,000 ventilated days. In 2021, 67 patients were mechanically ventilated in our ICU (patients who completed ventilation in that year). The total time spent on ventilation was 17,143 h or 714.3 days. As the criteria for ventilator-assisted pneumonia (VAP) is >48 h of ventilation, we excluded 19 patients who had been ventilated for 48 h or less. Among 48 patients who were ventilated for > 48 h, the total ventilation was 16,765 h or 698.5 days. We recorded 8 VAP in 714 days, which is 1 VAP per 89 days of ventilation or 11.2/1,000 ventilation days. Healthcare staff, especially registered nurses, play a major role in VAP prevention, providing care every day, all days of the week. Most prevention interventions and strategies are part of routine nursing care. Lack of knowledge about infection prevention and appropriate nursing care among nurses can become a barrier to adherence to evidence-based guidelines for the prevention of VAP.

CONCLUSION: This study will help nurses to learn about VAP and its prevention in detail so that they can apply the knowledge in clinical practice. Understanding the pathophysiology of VAP, its risk factors and the nursing care bundle is essential for appropriate prevention and treatment of VAP. Specific protocols, strategies, and active control should be available in each ICU regarding the care bundle.

Introduction

Cancer is the second leading cause of death [1]. As the number of cancer patients increases, all the professional challenges related to their management will become even greater. The treatment of cancer itself is challenging, as are all the side-effects that cancer patients face during the treatment process. In this article, incidence of ventilator-associated pneumonia (VAP) in our intensive care unit (ICU) and preventive measures and the role of nurses in VAP prevention. This study will help nurses to learn about VAP in detail so that they can apply this knowledge in clinical practice to prevent VAP.

Hospital-acquired infections are a common problem faced by patients in the ICU. Critically ill cancer patients are particularly vulnerable group who have additional, immutable risk factors for infections and are, in many cases, at increased risk of death as a result. The most common nosocomial infections acquired by cancer patients in the ICU are VAP, bloodstream infections, vascular catheter infections, urinary tract catheter-associated infections, and Clostridium difficile infections [2].

Mechanical VAPs a common complication in patients in ICU and significantly prolongs the length of stay, has a direct impact on mortality and increases the cost of treatment. Hospital-acquired pneumonia is more common in the 1st days of mechanical ventilation (MV): About half of all cases occur in the first 4 days (Klompas, 2019) [3], [4].

The risk of VAP is highest in the first 5 days of MV (3%) and the mean duration between intubation and the development of VAP is 3.3 days. This risk decreases between 2 and 5 days of ventilation to 2%/day, and then further to 1%/day. Previous studies have attributed mortality rates to VAP of between 33% and 50%, but this rate is variable and strongly dependent on the underlying medical illness. Over the years, the attributed risk of death has decreased and has recently been estimated at 9–13%, mainly due to the implementation of prevention strategies [5].

Pneumonia is an inflammation of the lung parenchyma. It can be divided according to the extent and location of lung involvement, the site of origin (community-acquired pneumonia or hospital-acquired pneumonia), and the clinical picture and causative agents [6]. The microbes causing hospital-acquired pneumonia enter the lower respiratory tract by aspiration of pharyngeal or gastric contents. As with any pneumonia, VAP occurs when bacteria penetrate the normally sterile lower airways and overcome the host's typical defense mechanisms against infection. Two mechanisms of entry of pathogens into the lower respiratory tract have been described: the most important is microaspiration of pathogens from the upper respiratory tract/intestinal tract around the inserted endotracheal tube, the second is the formation of a biofilm on the wall of the tube itself. The upper respiratory tract of most mechanically ventilated patients is colonized with potentially pathogenic microorganisms [7].

The diagnosis of pneumonia is clinical, radiological and microbiological. It is characterised by a newly formed productive, purulent sputum with bacterial presence, a characteristic physical appearance over the lungs and new or advanced shadowing on lung X-ray. Hospital-acquired pneumonia is defined by the centers of disease control and prevention (CDC) as a lower respiratory tract infection that was not present or not in progress at the time of admission to hospital (occurring 48 h after admission). VAP is defined as hospital-acquired pneumonia occurring 48 or more hours after endotracheal intubation. Despite clear criteria, the diagnosis of VAP is difficult [8].

VAP prolongs the ICU stay for additional 4–9 days, with a mortality rate twice as high as in non-VAP patients [9]. VAP is estimated to cause 36,000 deaths each year in the United States. In Europe, there are approximately 18,900 confirmed cases of VAP annually, with a mortality rate of 50–76% for severe cases [10]. In Korea, 52.6% of all pneumonia patients had VAP, with a mortality rate of 24–50%. Of these patients, 70% were in the high-risk group [11], which prolongs the hospitalization time, increases the cost of treatment and the risk of mortality. The incidence of VAP in Europe exceeds 18 cases per 1000 days of MV. It is an indicator of the quality of an individual ICU (Nosocomial pneumonia in 27 ICUs in Europe: perspectives from the EU-VAP/CAP study).

To prevent VAP, the idea of a "bundled approach" has emerged, that is, a package of interventions that addresses a group of post-intubation interventions. The Institute of Healthcare Improvement in the United States has published a VAP prevention bundle that includes four elements: Elevation of the head of the bed, prophylaxis of peptic ulcer disease (PUD), prophylaxis of deep vein thrombosis (DVT), and daily discontinuation of sedatives and assessment of readiness for extubation [12]. European countries have also published practice guidelines consisting of five categories that take into account the strengths and importance among VAP prevention interventions: non-ventilator circuit changes unless specifically indicated, alcohol hand hygiene, appropriately educated and trained staff, incorporation of sedation control and weaning protocols into patient care, and oral care with chlorhexidine [13]. The Korea disease control and prevention agency have also published a VAP prevention toolkit consisting of five categories that refer to standards for assessing health facilities based on CDC guidelines: Raising the head of the bed, daily discontinuation of sedatives and assessment of readiness for extubation, prophylaxis of PUD, prophylaxis of DVT, and provision of daily oral care using chlorhexidine [7].

Institutions around the world have published VAP prevention toolkits and conducted various studies to identify preventive measures, but the actual implementation of VAP prevention measures in clinical practice is unclear. This has been found to be highly correlated with the prevalence rate of the disease [14]. European researchers have studied the implementation of a prevention bundle in hospitals and reported that the compliance rate for all five categories of the bundle was low or that the measures were not consistently implemented [15]. However, it is important to know that the quality of work has been shown to influence the survival of patients in ICU [16].

Several additional risk factors have been shown to increase the incidence of VAP. They can be easily divided into categories that cannot be modified and those that can be modified. Non-modifiable risk factors include male sex, older age (over 60 years), chronic obstructive pulmonary disease, presence of a tracheostoma or skull injury, recent neurological surgery, acute respiratory distress syndrome, and multiple organ failure and coma. Modifiable risk factors include lying in the supine position, frequent oral care, excessive feeding, handling of respiratory devices (ventilator tubes), low endotracheal tube cuff pressure and repeated intubations, hand hygiene, and use of all preventive measures that help to reduce VAP.

Reducing pneumonia in the mechanically ventilated patient requires a multidisciplinary approach by all team members. Prevention of VAP should start with avoiding or limiting the duration of MV. Several strategies have been described to achieve this goal: non-invasive positive pressure ventilation (NPPV), reduction of sedation, attempts to wean from the ventilator, avoidance of reintubation, and early tracheostomy. Re-intubation is associated with a higher risk of VAP due to the higher aspiration rates [3]. We should focus on reducing the number of unplanned extubations requiring reintubation. Each extubation should be carefully considered. When planning weaning, physicians should be aware of the risks associated with reintubation and total MV time [14].

VAP is estimated to affect 5–40% [17] of patients on invasive MV for more than 2 days, with large

variations depending on the country, the type of ICU and the criteria used to identify VAP and differences in microbiological sampling methods. In North American hospitals, the rate of VAP is reported to be only 1–2.5 cases per 1000 ventilator days. European centers report much higher rates. For example, the EU-VAP/CAP study reported an incidence density of 18.3 VAP cases per 1000 ventilator days. The daily risk of VAP peaks between days 5 and 9 of MV, while the cumulative incidence is closely related to the total duration of MV [17]. Incidence rates vary widely according to the population studied. VAP rates of 24.5/1000 ventilation days have been reported in cancer patients [3].

Pathophysiology

MV is an effective method to save the life of critically ill patients and is widely used in ICU. However, prolonged MV can lead to an increased risk of infections and various complications. To understand and follow strategies for VAP prevention, nurses need to be educated with the pathophysiology of VAP. Depending on the time elapsed from the initiation of MV to the onset of pneumonia, can be divided into two types: Early and late onset. Early onset occurs 48–96 h after intubation and is associated with antibiotic-sensitive organisms [18].

Common causative agents of VAP are Gram-negative bacilli such as *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella pneumoniae* and *Acinetobacter*, and Gram-positive cocci such as *Staphylococcus aureus. P. aeruginosa* is the most common causative agent of VAP [19]. In recent years, the number of multidrug-resistant (MDR) pathogens has been increasing due to prior antibiotic treatment. Analysis of the etiology of VAP in a tertiary hospital showed that in early VAP, *Enterobacteriaceae and S. aureus* were the main pathogens, in late VAP, non-fermenting bacteria and *Enterobacteriaceae* were the main pathogens, and 60.8% of the bacterial pathogens were MDR strains. The study included 100 patients with clinically diagnosed VAP, 35 of whom were diagnosed with VAP by quantitative culture of endotracheal aspirates. According to the risk factor assessment, prior antibiotic treatment and hospitalization for more than 5 days were independent risk factors for drug resistance of VAP agents [20]. In addition, an etiological study of 397 patients with VAP also showed that prolonged exposure to unnecessary antibiotics was one of the strongest predictors of antibiotic resistance. Multivariate logistic analysis identified exposure to prophylactic antibiotics and multiple inappropriate antibiotic treatments as independent risk factors for MDR VAP [21]. Although the distribution of VAP pathogens in ICUs varies according to patient population, diagnostic methods, duration of hospitalization and antibiotic policy, there is a consistent trend of increasing numbers of MDR strains. There are, of course, numerous reports that prophylactic use of antibiotics can reduce the incidence and mortality of VAP, but it is undeniable that prolonged prophylactic use of antibiotics can induce changes in drug resistance in the causative agents, making treatment more difficult.

Colonization of the airways and digestive tract and microaspiration of secretions from the upper and lower airways are risk factors of VAP. VAP develops when bacteria colonize the lung parenchyma or lower airways of a patient receiving MV. Aspiration of secretions or the use of contaminated equipment can spread the organisms through the throat, sinus cavities, nostrils, plaque, gastrointestinal tract, patient-to-patient contact, and the ventilator circuit, leading to bacterial colonization of the lungs [22].

In addition, prolonged ventilation increases the risk of infection caused by humidifiers and ventilator loops, which are a source of pathogens due to exposure [23]. Most ICUs are closed units and air circulation is not smooth. Exhaled gases and secretions from patients in ICUs contain a large number of pathogens that cause air contamination. As the length of hospital stay increases, so does the potential for hospital-acquired infections. The physiological reflexes of patients with impaired consciousness, such as swallowing, coughing, and expectoration, are impaired, which affects the secretion of respiratory secretions. In addition, patients with disorders of consciousness are in a passive position; they are not able to cooperate well with health-care staff in carrying out certain clinical interventions. Therefore, passive suctioning of sputum may lead to reflux of gastric contents and aspiration. Micro or macro aspiration of oropharyngeal or gastric fluids is an essential step in the development of VAP. As the stomach can serve as a reservoir for bacteria, aspiration of gastric contents may be another possible cause of VAP. Patients receiving MV mostly have a nasogastric or orogastric tube for enteral feeding, administration of medications or gastric decompression. The presence of a nasogastric or orogastric tube interrupts the gastroesophageal sphincter, causing increased gastrointestinal reflux, allowing bacteria to move into the oropharynx and colonize the upper airway. Enteral feeding increases gastric pH and gastric volume, which increases the risk of bacterial colonization and aspiration, and consequently can lead to infection [24].

The presence of an endotracheal tube allows direct entry of colonized bacteria into the lower airway. Secretions from the upper airway and oral cavity collect above the cuff of the tube. The pools line the tube, forming a biofilm and containing a large amount of bacteria that can be spread to the lungs by ventilator-induced breaths, which can be removed by injecting saline into the tube, suctioning, coughing, or repositioning the tube. Endotracheal tubes cause an unusual disconnection between

the upper airway and the trachea, allowing bacteria to pass directly into the lower airway and bypass the upper airway. The presence of bacteria in the lower airway reduces the body's ability to filter and humidify the air. The cough reflex is often reduced or eliminated by the presence of such a tube, and mucociliary clearance may be impaired. In addition, the endotracheal tube allows bacteria to bind in the trachea, leading to an increase in mucus production and secretion [25], impairing the host's natural defense mechanisms, increasing the likelihood of bacterial colonization and subsequent aspiration of colonized organisms.

Risk Factors

The diagnosis is made on the basis of radiographic findings, clinical findings and the results of sputum microbiological tests, such as culture and sensitivity, or invasive tests, such as bronchoscopy. Findings on chest radiographs are not reproducible and should not be used alone for the diagnosis of VAP, as pulmonary infiltrates seen on chest radiographs in patients receiving MV may be due to atelectasis, aspiration, pulmonary embolism, pulmonary edema, alveolar hemorrhage, pulmonary infarction, and acute respiratory distress syndrome [26].

Every intubated patient receiving ventilatory support is at risk of VAP. There are different types of risk factors, which can be divided into three categories: Host-related factors, factors device-related factors, and personnel. Host-related risk factors include previous diseases such as immunosuppression, chronic obstructive pulmonary disease, and acute respiratory syndrome respiratory distress syndrome. Other host-related factors include the physical position of the patients, high age, level of consciousness, number of intubations, blood transfusion and medications, including sedatives and antibiotics. The reduction in level of consciousness results in loss of cough reflexes and esophageal reflux and increases the risk of aspiration and VAP [27].

Risk factors associated with installations include endotracheal tube, ventilator circuit and presence of nasogastric or orogastric tube. When the patient is in the supine position, pulmonary aspiration is increased and secretions collect above the cuff of the endotracheal tubes. At low cuff pressures, such pools can cause microaspiration or bacterial leakage around the cuff into the trachea. In addition, nasogastric and orogastric tubes also interfere wit gastroesophageal sphincter, causing reflux, and increasing the risk of VAP [27].

Walaszek *et al.* found that invasive medical interventions, including re-intubation, tracheostomy and fiberoptic bronchoscopy, are important risk factors for VAP in the ICU [28]. The previous studies have also shown that reintubation, endotracheal sputum aspiration, fiberoptic bronchoscopy, tracheostomy, and nasogastric tube insertion were significantly associated with VAP [29].

In addition to the above risk factors that have been extensively studied [30] showed that smoking is one of the strongest predictive factors for the development of VAP. They found that the incidence of VAP in smokers was 4.37 times higher than the incidence of VAP in patients who did not smoke or had quit smoking. This may be because long-term smoking leads to impaired lung macrophage function, which reduces bacterial clearance and makes the lungs vulnerable to attack by pathogenic bacteria. Papakrivou *et al.* found intra-abdominal hypertension to be an independent risk factor for VAP in ICU patients in a prospective single-center study. Recent studies have shown that intra-abdominal hypertension increases the risk of infection by severely affecting the function of the respiratory system and peripheral organs. In addition, elevated intra-abdominal pressure increases the risk of inhalation of gastric contents contaminated with pathogenic microorganisms [31].

The Nurse's Role in VAP Prevention

The prevention package is a set of key interventions, derived from evidence-based guidelines, which are intended to improve patient outcomes. Preventive measures are based on the pathophysiology and etiology of pneumonia, the mode of MV and the duration of ventilation.

To prevent and reduce VAP, appropriate multidisciplinary approaches and measures should be used in ICU, starting at intubation or, if possible, before intubation, and continuing until extubation [22]. Emphasis should be placed on preventing microaspiration of subglottic secretions, preventing colonization of the oropharynx and preventing contamination of ventilator equipment.

Infection prevention is the daily work of nurses in every hospital. They create and ensure a safe environment, take responsibility for nursing care and play a key role in preventing hospital-acquired infections. Nurses guide healthcare workers in implementing preventive strategies to protect patients from infections. Thus, lack of knowledge about infection prevention and appropriate nursing care can become a barrier to adherence to evidence-based guidelines for the prevention of VAP. This is because ICU nurses are in constant contact with the patient, providing nursing care, performing most of the procedures associated with MV and directing others who are in contact with the patient, such as students, healthcare workers and visitors. In addition, they must integrate knowledge, skills and responsibility during the delivery of nursing care to the patient. From the time of patient admission onwards, nurses must systematically

follow a nursing process consisting of assessment, planning, implementation, and evaluation [22].

Nurses perform most of the procedures related to MV and therefore need to have adequate knowledge of NPPV, daily suction attempts, sedation breaks, aspiration prevention, subglottic suctioning of endotracheal tubes, ET tube cuff pressure and bed head elevation. This knowledge should be correctly applied in practice to reduce the risk of VAP. Nurses should maintain accurate documentation and reports conduct in-service education of health-care staff on infection prevention and provide appropriate health education counseling to visitors. Nurses are fully responsible for the overall care of the patient from admission to discharge. They are one of the members of the healthcare team who devote most of their time to patient care and therefore play an important role in VAP prevention. However, knowledge alone is not enough, it is also essential to apply it in the right place and at the right time, providing comprehensive nursing care according to the patient's needs. This is why critical care nurses play the most important role in VAP prevention.

Methods

This review article "VAP and the role of nurses in its prevention" is based on a summary of evidence from the literature and guidelines from the CDC as well as original research and review articles published in various medical journals. English language publications from 2015 to 2023 were searched in PubMed, Google Scholar, Science Direct, Medline, and Wiley Online Library.

Our ICU at the Institute of Oncology has 10 beds. It mainly takes care of the early post-operative course of surgical patients, but we accept patients from all departments of the Institute. It provides intensive care for internal medicine, surgery, and radiotherapy patients. The number of patients admitted to the ICU is increasing year on year. The number of patients on MV is also increasing, so from October 1, 2019, we started monitoring VAP to determine the quality of work in the ward. A protocol for the diagnosis of VAP according to the CDC, and a protocol on risk factors has been developed. Graduate nurses recorded risk factors in all intubated patients in all 3 shifts, and the diagnosis protocol is completed by the physician in case of antibiotic introduction in suspected VAP. Patients intubated in the ICU all have a tube that allows subglottic traction. Patients were not routinely reintubated if they were intubated outside the ICU with a tube that does not allow subglottic aspiration. It should be mentioned that after 3–4 weeks of MV, patients were tracheotomized (surgical procedure, percutaneous tracheotomy).

Results

Figure 1 shows the groups of patients admitted to the ICU at the Ljubljana Institute of Oncology in 2021.

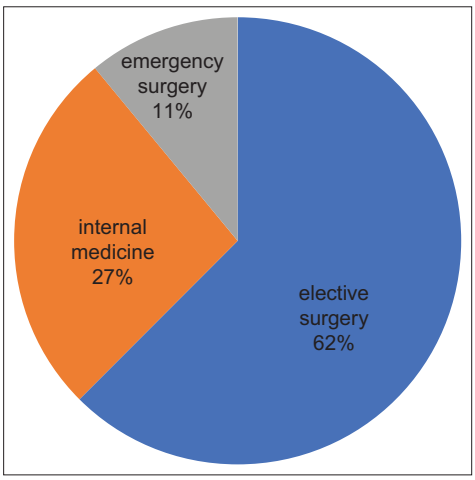

Figure 1: Patient groups admitted to the ICU in 2021

In 2019, we started prospectively monitoring risk factors for VAP and its incidence. A protocol for the diagnosis of VAP according to the CDC. Registered nurses recorded risk factors in all intubated patients, every day in all three shifts, and the diagnosis protocol was completed by the physician in cases where antibiotic therapy was initiatiated in suspected VAP.

In Table 1, we have outlined the package of actions in our ICU that nurses carry out on a daily basis in the morning, in the afternoon and at night. For each patient on MV, we have a form next to the nursing process that includes the preventive measures we have described in the table. In Table 2 we can see Incidence of VAP from 2019 to 2021.

The total number of VAP cases in 2021 among the 48 patients ventilated for more than 48 h was 16,765 h or 698.5 days. There were 8 VAPs in 714 days, which is 1 VAP per 89 days of MV, or 12.6/1,000 ventilated days.

Discussion

Oncology nursing is a specific area. Nurses working with oncology patients, needs to be aware of their specific characteristics and tailor the treatment accordingly. Cancer treatment involves a combination of different treatments that affect the patient's condition. Surgery, chemotherapy, and radiotherapy are the most common treatments for cancer patients. The nurse needs to be aware of the acute and long-term side effects caused by the treatment methods. Because of these side effects and deterioration in health, the patient may need MV.

Table 1: VAP bundle of preventive measures that are implemented on a daily basis in the our intensive care unit

VAP bundle of preventive measures that are implemented on a daily basis in the our intensive care unit; in all three shifts	
Year	Active surveillance for VAP
2021	
	Prevention of aspiration of oral-pharyngeal secretions (placing the patient in a semi-sitting position at an angle of 30–45°) if not contraindicated.
	Appropriate antibiotic use.
	Performing aspiration from the subglottic space
	(all patients have a contralateral/intermittent traction device)
	Turn patients at least every 2 h.
	Change the ventilator circuit when visibly soiled.
	Closed airway aspiration
	Change the respiratory system only when it is visibly dirty
	Performing oral hygiene with antiseptics and mechanical tooth brushing
	Use of silver-coated ultra-thin polyurethane endotracheal tubes
	Automatic control of the pressure in the endotracheal tube (20–30 cm H20)
	Reduce sedation (avoid sedation)
	Using active humidification
	Daily assessment of the patient's readiness for extubation
	Daily assessment of fan discharge potential
	Controlling the volume of food left in the stomach
	Education of healthcare workers regarding nosocomial infection prevention.
	Early tracheostomy
	Avoided intubation and re-intubation if possible (Use of noninvasive, BiPAP or other strategies) and improving planned extubations with the design of protocols to improve quality of weaning
	RASS assessment every 4 h

RASS: Richmond agitation sedation scale.

Patients admitted to our ICU have a weakened immune response, often after chemotherapy or radiotherapy, have toxic effects of drugs on their organs, anemia, and are prone to bleeding, nausea and vomiting, on vasoactive support, some after resuscitation, septic and hemodynamically unstable. They are often elderly, with comorbidities, altered metabolism. They have and further lose muscle mass with prolonged MV, all of which leads to a poor functional status of the patient.

In the results, we wanted to accurately demonstrate the day-to-day implementation of a bundle of preventive measures to prevent pneumonia in mechanically ventilated patients. The measures are implemented by nurses in all patients, in all three shifts. Unfortunately, we do not have a comparison or no significant differences in the incidence of VAP for the period before we started to monitor the consistency of the implementation of the preventive measures.

We started the consistent implementation of the CDC measures in 2019 and this is a very short observation period, but despite this, we have found that we can make further improvements in some of the measures, especially in the area of nurse education, enhanced oral care, and encouraging doctors to review protocols on an ongoing basis, whether pneumonia is present or not. Prophylaxis to reduce DVT and PUD is important aspects of the VAP bundle [27], we also see opportunities for improvement in this area in our unit. However, despite the regular implementation of preventive measures to prevent pneumonia in mechanically ventilated patients, we found that the incidence is comparable to European guidelines on the incidence of VAP, where 18,9/1.000 days confirmed cases of VAP annually, with a mortality rate of 50–76% for severe cases [10], we have 12.6/1,000 days.

Table 2: Incidence of VAP from 2019 to 2021

Incidence of VAP		
Year 9–12 2019	153 patients, 20 (13%) on mehanical ventilation	2 VAP Incidence: 10.5/1,000 days
Year 2020	461 patients, 74 (16%) on mehanical ventilation	8 VAP Incidence: 11.9/1,000 days
Year 2021	475 patients, 67 (14%) on mechanical ventilation; 48 patients ventilated for more than 48 h	8 VAP Incidence: 12.6/1,000 days

VAP: Ventilator-associated pneumonia.

At present, VAP preventive measures are being implemented for the above risk factors, such as adherence to NPPV for some types of respiratory failure, attempting spontaneous breathing and attempting daily awakenings to reduce MV, and hospitalization times; rising the head of the bed to 30–45°, reducing unnecessary suctioning of sputum and reducing ventilatory circuit replacement to reduce aspiration; selective decontamination of the gastrointestinal tract and selective decontamination of the oropharynx to reduce colonization of drug-resistant bacteria [32]. Although studies have shown that long-term prophylactic antibiotic use can lead to changes in pathogen resistance, other studies have confirmed that early (<7 days) empiric antibiotic use in the ICU can reduce the incidence of VAP [33]. A study showed that β-lactam antibiotics such as piperacillin-tazobactam can reduce the incidence of early VAP but have little effect on the incidence of late VAP [34]. In addition, the use of probiotics can reduce the ICU admission time and hospitalization time of patients with VAP, but the use of probiotics has no significant effect on diarrhea-causing bacteria colonizing the stomach and pharynx, nor on the incidence of MDR pathogens [35].

Given the magnitude of healthcare-associated respiratory infections, on the one hand, and the numerous prevention options, on the other hand, many authors are concerned with providing guidance on how appropriate policies, strategies, and management guidelines in hospitals can help to reduce infection rates. Developing prevention strategies is crucial. Developing guidelines alone is not enough, as adherence to the guidelines by healthcare staff is crucial, which also needs to be specifically addressed by the hospital through training, familiarization, supervision and motivation of all members of the health-care team [5]. In our unit, following the recommendations of the CDC [36], we have started in 2019.

We have focused on the fact that all patients on MV have their head elevated 30–45°, and the pressure in the endotracheal tube is set to be measured continuously by the machine or directly through the ventilator between 20 and 30 mmHG in all patients. The pressure in the endotracheal tube cuff should be maintained at 20–30 cm H_2O. Care must be taken not to increase the pressure excessively, as it may cause ischemia of the tracheal mucosa and tracheal injury [7]. We use polyurethane endotracheal tubes with additional lumen for subglottic aspiration. A subglottic aspiration apparatus and a closed endotracheal aspiration system are used in all patients. We only replace the respiratory system when it is visibly soiled.

Oral care in 2021 was performed 3 times a day with 0.12% chlorhexidine (CHG), now we have double-sided brushes with the possibility of aspirating oral secretions and we perform oral care every 4 h. The authors recommend oral hygiene 2–6 times a day, advising the use of alcohol or chlorhexidine [5]. The Betsy Lehman Centre [37] and the [38] recommend that health-care personnel perform oral hygiene every 4 h or 6–8 h. CHG has a broad spectrum of activity, is antimicrobials effective and prevents plaque formation. The disadvantages of using CHG are that it can cause staining of the teeth if used over a long period of time, it can cause irritation and scaling of the oral mucosa, bleeding gums, it has a bad taste and can cause burns [39]. The nurse plays a very important role in the prevention of VAP by providing nursing care that includes oral hygiene [39]. The use of appropriate CHG solutions, when performing oral hygiene in intubated patients, significantly reduces the incidence of VAP [40], [41] state that it is not possible to select the optimal oral hygiene solution and that the selection should be tailored to the oral condition, which is of utmost importance for oncology patients who may be treated with chemotherapy and/or radiotherapy. Munro [42] investigated the use of CHG for mouth rinses before and after intubation, which proved to be effective in both cases. The use of CHG before intubation could be a novelty in elective procedures that may prove to be a good solution to reduce the incidence of VAP. Povšič [43] states that in critically ill patients, the oral flora changes rapidly after admission to the ICU. Due to immunosuppression and the presence of an endotracheal tube, the protective mechanisms of the respiratory tract are weakened. The endotracheal tube opens the route for bacteria from the upper respiratory tract to the lower respiratory tract, inhibits the cough reflex, damages the tracheal epithelium, reduces mucociliary activity. and bacterial clearance. Colonization of the respiratory tract by bacteria increases in the face of weakened immunity and leads to infection of the lung parenchyma. However, correct and prompt antibiotic treatment improves survival.

Oral care can reduce the proliferation of bacteria colonizing the oral cavity and pharynx. Disinfecting the oral cavity with 0,12% chlorhexidine is an effective method to prevent the occurrence of VAP and reduce oral colonization, particularly to reduce the number of Gram-positive bacteria [44]. In our unit, we try to avoid intubation whenever possible, and we also assess the patient's readiness for extubation on a daily basis. The most common Richmond agitation sedation scale was between −3 and −4. We try to reduce sedation on a daily basis. Most intubated patients received a nasogastric tube (14 CH) within 24–48 h and were enterally fed. We check the volume of food in the stomach every 8 h. Probiotics are also used in the feeding. We had one self-excubation in 2021, which we reported as a safety deviation. We use active humidification for MV and aim for early tracheostomy. In practice, we always aspirate secretions from the mouth before transporting the patient for investigations. Furthermore, important to prevent pneumonia in mechanically ventilated patients is turning the patient every 2–3 h if their condition allows [45].

Hand hygiene of healthcare staff plays a very important role in the prevention of VAP. Hand hygiene is one of the quality indicators in our hospital. We follow the WHO guidelines of the "5 hand hygiene trends." The hand hygiene consistency of the ICU in the 1st half for 2022 is 92.2%. The World Health Organization (2022) states that hand hygiene is one of the most important measures in the prevention of healthcare-associated infections. Hand hygiene includes: Hand washing, hand disinfection, gloves use, hand skin care, and non-touch technique.

VAP is one of the most common nosocomial infections in ICU and is associated with high morbidity and high cost of care. The pathophysiology, epidemiology, treatment, and prevention of VAP have been intensively studied for decades, but a clear prevention strategy has not yet been developed. We recommend a multidisciplinary strategy for the prevention of VAP. Interventions that have been shown to have clinical impact include: (i) NPPV for fit patients, especially in immunocompromised patients, with acute exacerbation of chronic obstructive pulmonary disease or pulmonary edema, sedation, and ventilator weaning protocols, MV protocols including elevation of the bed head above 30° and oral care, and removal of subglottic secretions. Other measures such as selective decontamination of the gastrointestinal tract, selective decontamination of the larynx and endotracheal tubes coated with antimicrobial agents have also been tested in various studies. However, the evidence on the effectiveness of these measures to reduce VAP rates is not strong enough to recommend their use in clinical practice [46]. Knowledge of risk factors and consistent implementation of preventive measures are of paramount importance [43].

The VAP prevention package not only requires the joint use of several preventive measures, but also the implementation of safety education for health-care staff and patients to better improve the operational capacity of health-care staff and patient compliance [10].

Conclusion

VAP is a common infectious complication among ICU patients treated with MV for 48 h or longer, contributing to a significant increase in morbidity, mortality, hospital costs, and length of stay. Health systems have an important role to play in the prevention of VAP through the development of strategies and guidelines and their consistent implementation. To prevent and reduce the rate of VAP, ICUs should use successful multidisciplinary approaches and provide education for all healthcare providers focusing on risk factors and preventive

measures for VAP. The VAP prevention strategies have been combined into a prevention bundle in the hope that routine, coordinated implementation of the selected measures in collaboration with all team members will yield better results than any single measure, which has to be successful in our hospital, with incidence (12.6/1,000 days) of mechanical VAP in 2021. In this paper, we describe the measures that we perform on a daily basis in patients who are on MV.

Reducing VAP can only be achieved with the collaboration of all members of the healthcare team and by adhering to and consistently implementing all VAP prevention measures. This is especially important for critically ill cancer patients. VAP cannot be completely prevented, but it can be effectively limited with the right approach and, above all, by educating and sensitizing registered nurses to the importance of consistent implementation of preventive measures.

Acknowledgment

The author would like to thank all participants for their participation in the data collection.

Author Contributions

All authors developed the concept and design of study and participated in critical revisions of the manuscript.

References

1. World Health Organization. Noncommunicable Diseases Progress Monitor. Geneva: World Health Organization; 2022.
2. Chadani O, Deepa W, Bimala P, Qinghua Z. Ventilatorassociated pneumonia and role of nurses in its prevention. J Nepal Med Assoc. 2017;56(208):461-8.
   PMid:29453481.
3. Battaglia CC, Hale K. Hospital-acquired infections in critically ill patients with cancer. J Intensive Care Med. 2019;34(7):523-36. https://doi.org/10.1177/0885066618788019
   PMid:30012057
4. Wu D, Wu C, Zhang S, Zhong Y. Risk factors of ventilator-associated pneumonia in critically III patients. Front Pharmacol. 2019;10:482. https://doi.org/10.3389/fphar.2019.00482
   PMid:31143118
5. Kalanuria AA, Ziai W, Mirski M. Ventilator-associated pneumonia in the ICU. Crit Care. 2014;18(2):208. https://doi.org/10.1186/cc13775
   PMid:25029020
6. Zupanc TL, Pokorn M. Bolnišnična pljučnica. In: Tomaţič J, Strle F, editors. Infekcijske Bolezni. Ljubljana: Zdruţenje za Infektologijo, Slovensko Zdravniško Društvo; 2014. p. 272-80.
7. Fernando SM, Tran A, Cheng W, Klompas M, Kyeremanteng K, Mehta S, *et al*. Diagnosis of ventilator-associated pneumonia in critically ill adult patients-a systematic review and meta-analysis. Intensive Care Med. 2020;46(6):1170-9. https://doi.org/10.1007/s00134-020-06036-z
   PMid:32306086
8. McEnery T, Martin-Loeches I. Predicting ventilator-associated pneumonia. Ann Transl Med. 2020;8(11):670. https://doi.org/10.21037/atm.2020.03.173
   PMid:32617290
9. Álvarez-Lerma F, García MS. The multimodal approach for ventilator-associated pneumonia prevention-requirements for nationwide implementation. Ann Transl Med. 2018;6(21):420. https://doi.org/10.21037/atm.2018.08.40
   PMid:30581828
10. Kim EJ, Kwak YG, Kwak SH, Ko SH, Kim JH, Kim ES, *et al*. Korean national healthcare-associated infections surveillance system, intensive care unit module report: Summary of data from July 2018 to June 2019. Korean J Healthc Assoc Infect Control Prev. 2020;25(2):115-27.
11. Institute for Healthcare Improvement. Getting started kit: Prevent ventilator-associated pneumonia: How-to guide. Crit Care Nurs Q. 2006;29(2):157-73. https://doi.org/10.1097/00002727-200604000-00010
    PMid:16641653
12. Rello J, Lode H, Cornaglia G, Masterton R, Masterton R, Rello J, *et al*. A European care bundle for prevention of ventilator-associated pneumonia. Intensive Care Med. 2010;36:773-80.
13. Jahansefat L, Vardanjani MM, Bigdelian H, Massoumi G, Khalili A, Mardani D. Exploration of knowledge of, adherence to, attitude and barriers toward evidence-based guidelines (EBGs) for prevention of ventilator-associated pneumonia (VAP) in healthcare workers of pediatric cardiac intensive care units (PCICUs): A quali-quantitative survey. Int J Med Res Health Sci. 2016;5(9):67-73.
14. Agodi A, Barchitta M, Quattrocchi A, Spera E, Gallo G, Auxilia F, *et al*. Preventable proportion of intubation-associated pneumonia: Role of adherence to a care bundle. PLoS One. 2017;12(9):e0181170. https://doi.org/10.1371/journal.pone.0181170
    PMid:28877171
15. Aiken LH, Sloane DM, Bruyneel L, Van den Heede K, Griffiths P, Busse R, *et al*. Nurse staffing and education and hospital mortality in nine European countries: A retrospective observationalstudy. Lancet. 2014;383(9931):1824-30. https://doi.org/10.1016/S0140-6736(13)62631-8
    PMid:24581683
16. Papazian L, Klompas M, Luyt CL. Ventilator-associated pneumonia in adults: A narrative review. Intensive Care Med. 2020;46(5):888-906. https://doi.org/10.1007/s00134-020-05980-0
    PMid:32157357
17. Stoclin A, Rotolo F, Hicheri Y, Mons M, Chachaty E, Gachot B, *et al*. Ventilator-associated pneumonia and bloodstream infections in intensive care unit cancer patients: A retrospective 12-year study on 3388 prospectively monitored patients. Support Care Cancer. 2020;28(1):193-200. https://doi.org/10.1007/s00520-019-04800-6
18. Oliveira J, Zagalo C, Cavaco-Silva P. Prevention of ventilator-associated pneumonia. Rev Port Pneumol. 2014;20(3):152-61. https://doi.org/10.1016/j.rppneu.2014.01.002
    PMid:24674617
19. Evans CR, Sharpe JP, Swanson JM, Wood GC, Fabian TC,

Croce MA, *et al*. Keeping it simple: impact of a restrictive antibiotic policy for ventilator-associated pneumonia in trauma patients on incidence and sensitivities of causative pathogens. Surg Infect (Larchmt). 2018;19(7):672-8. https://doi.org/10.1089/sur.2018.087
PMid:30204541

20. Mahapatra A, Patro S, Sarangi G, Das P, Mohapatra D, Paty B, *et al*. Bacteriological profile of ventilator-associated pneumonia in a tertiary care hospital. Indian J Pathol Microbiol. 2018;61(3):375-9. https://doi.org/10.4103/ijpm.ijpm_487_16
PMid:30004058
21. Lewis RH, Sharpe JP, Swanson JM, Fabian TC, Croce MA, Magnotti LJ. Reinventing the wheel: Impact of prolonged antibiotic exposure on multidrug-resistant ventilator-associated pneumonia in trauma patients. J Trauma Acute Care Surg. 2018;85(2):256-62. https://doi.org/10.1097/TA.0000000000001936
PMid:29664891
22. Osti C, Wosti D, Pandey B, Zhao Q. Ventilator-associated pneumonia and role of nurses in its prevention. J Nepal Med Assoc. 2017;56(208):461-8.
PMid:29453481.
23. Ding C, Zhang Y, Yang Z, Wang J, Jin A, Wang W, *et al*. Incidence, temporal trend and factors associated with ventilator-associated pneumonia in mainland China: A systematic review and meta-analysis. BMC Infect Dis. 2017;17(1):468. https://doi.org/10.1186/s12879-017-2566-2567
PMid:28676087
24. Ferrer R, Artigas A. Clinical review: Non-antibiotic strategies for preventing ventilator-associated pneumonia. Critic Care. 2001;6(1):45-51. https://doi.org/10.1186/cc1452
PMid:11940265
25. De Rosa FG, Craven DE. Ventilator-associated pneumonia: Current management strategies. Infect Med. 2003;20(5):248-59.
26. Augustyn B. Ventilator-associated pneumonia risk factors and prevention. Crit Care Nurse. 2007;27(4):32-9.
PMid:17671243
27. Walaszek M, Kosiarska A, Gniadek A, Kołpa M, Wolak Z, Dobroś W, *et al*. The risk factors for hospital-acquired pneumonia in the intensive care unit. Przegl Epidemiol. 2016;70(1):107-10.
PMid:27344468
28. Thatrimontrichai A, Rujeerapaiboon N, Janjindamai W, Dissaneevate S, Maneenil G, Kritsaneepaiboon S, *et al*. Outcomes and risk factors of ventilator-associated pneumonia in neonates. World J Pediatr. 2017;13:328-34. https://doi.org/10.1007/s12519-017-0010-10
29. Liu Y, Di Y, Fu S. Risk factors for ventilator-associated pneumonia among patients undergoing major oncological surgery for head and neck cancer. Front Med. 2017;11(2):239-46. https://doi.org/10.1007/s11684-017-0509-8
PMid:28493197
30. Papakrivou E, Makris D, Manoulakas E, Karvouniaris M, Zakynthinos E. Intra-abdominal hypertension is a risk factor for increased VAP incidence: A prospective cohort study in the ICU of a tertiary hospital. J Intensive Care Med. 2018a;35(7):700-7. https://doi.org/10.1177/0885066618779369
PMid:29902954
31. Guillamet CV, Kollef MH. Is zero ventilatorassociated pneumonia achievable? practical approaches to ventilator-associated pneumonia prevention. Clin Chest Med. 2018;39(4):809-22. https://doi.org/10.1016/j.ccm.2018.08.004
PMid:30390751
32. Bouglé A, Tuffet S, Federici L, Leone M, Monsel A, Dessalle T, *et al*. Comparison of 8 versus 15 days of antibiotic therapy for *Pseudomonas aeruginosa* ventilator-associated pneumonia in adults: A randomized, controlled, open-label trial. Intensive Care Med. 2022;48(7):841-9. https://doi.org/10.1007/s00134-022-06690-5
PMid:35552788
33. Mirtalaei N, Farazi A, Monfared ME, Jokar A. Efficacy of antibiotic prophylaxis against ventilator-associated pneumonia. J Hosp Infect. 2019;101(3):272-5. https://doi.org/10.1016/j.jhin.2018.08.017
PMid:30179656
34. Mahmoodpoor A, Hamishehkar H, Asghari R, Abri R, Shadvar K, Sanaie S. Effect of a probiotic preparation on ventilator-associated pneumonia in critically ill patients admitted to the intensive care unit: A prospective double-blind randomized controlled trial. Nutr Clin Pract. 2019;34(1):156-62. https://doi.org/10.1002/ncp.10191
PMid:30088841
35. Centers for Disease Control and Prevention. Summary for Healthcare Facilities: Strategies for Optimizing the Supply of N95 Respirators during the COVID-19 Response. United States: Centers for Disease Control and Prevention; 2019. Available from: https://www.cdc.gov [Last accessed on 2020 Jan 15].
36. Bardwell J, Brimmer S, Davis W. Implementing the ABCDE bundle, critical-care pain observation tool, and richmond agitation-sedation scale to reduce ventilation time. AACN Adv Crit Care. 2020;31(1):16-21. https://doi.org/10.4037/aacnacc2020451
PMid:32168511
37. Institute for Clinical Systems Improvement. Health Care Protocol: Prevention of Ventilator-Associated Pneumonia. 5th ed. Bloomington, MN, USA: Institute for Clinical Systems Improvement; 2011. p. 1-30.
38. Safarabadi M, Ghaznavi-Rad E, Pakniyat A, Rezaie K, Jadidi A. Comparing the effect of echinacea and chlorhexidine mouthwash on the microbial flora of intubated patients admitted to the intensive care unit. Iran J Nurs Midwifery Res. 2017;22(6):481-5. https://doi.org/10.4103/ijnmr.IJNMR_92_16
PMid:29184589
39. Dikmen Y, Filiz NY. A recent view and evidence-based approach to oral care of intensive care patient. Int J Caring Sci. 2016;9(2):1177-85.
40. Meidani M, Khorvash F, Abbasi S, Cheshmavar M, Tavakoli H. Oropharyngeal irrigation to prevent ventilator-associated-pneumonia: Comparing potassium permangenate with chlorhexidine. Int J Prev Med. 2018;9:93. https://doi.org/10.4103/ijpvm.IJPVM_370_17
PMid:30450176
41. Munro CL. Oral health: Something to smile about! Am J Crit Care. 2014;23(4):282-8. https://doi.org/10.4037/ajcc2014440
PMid:24986168
42. Povšič Kerin M. Pneumonia in the intensive care unit. In: Petrovec M, editor. 5th Banič Days-Healthcare Associated Infections. Proceedings of the meeting, Šempeter pri Novi Gorici, November 2013;52(6):42-8.
43. Zand F, Zahed L, Mansouri P, Dehghanrad F, Bahrani M, Ghorbani M. The effects of oral rinse with 0.2% and 2% chlorhexidine on oropharyngeal colonization and ventilator associated pneumonia in adults' intensive care units. J Crit Care. 2017;40:318-22. https://doi.org/10.1016/j.jcrc.2017.02.029
PMid:28320561
44. O'Malley CA. Device cleaning and infection control in aerosol therapy. Respir Care. 2015;60(6):917-30. https://doi.org/10.4187/respcare.03513
PMid:26070583
45. Keyt H, Faverio P, Restrepo MI. Prevention of ventilator-associated pneumonia in the intensive care unit: A review of the clinically relevant recent advancements. Indian J Med Res. 2014;139(6):814-21.
PMid:25109715