Risk factors and preventable strategies of ventilator-associated pneumonia: the role of nursing care and epidemiological surveillance

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ABSTRACT

Mechanically ventilated patients are at risk of several complications, including ventilator-associated pneumonia (VAP). VAP is the most common nosocomial infection in this group of hospitalized patients. As a nosocomial infection, it is an undesirable event and is associated with prolonged hospitalization, high costs, and high mortality. To minimize the incidence and provide safe care for mechanically ventilated patients, it is recommended that VAP prevention procedures be developed and implemented, which take into account the general principles of infection prevention such as hand hygiene, isolation, and personal protective equipment, as well as risk factors associated with the treatment, which include, among others, patient position, nutrition, oral hygiene, and tracheobronchial toilet. Knowledge of ventilator operation and decontamination of medical equipment are also of great importance in the prevention of VAP. Collaboration between the patient care staff and the and the infection control team is equally important. Effective VAP surveillance systems can significantly reduce the risk of its occurrence.

The aim of this study is to present the issues of VAP with particular emphasis on risk factors for the disease, nursing care, and epidemiological surveillance on the basis of a literature review. The work is dedicated to both epidemiological nurses employed in infection control teams and nurses working in intensive care units, where patients requiring mechanical ventilation are hospitalized, as well as representatives of other professions (e.g. physiotherapists, nutritionists) taking care of patients hospitalized in intensive care units (ICUs).

Key words: VAP, ICU, risk factors, nursing care, epidemiological surveillance.

INTRODUCTION

Health care-associated infections (HAI) are a frequent and in many cases fatal complication of hospital treatment. A special type of nosocomial infection is pneumonia. Hospital-acquired pneumonia (HAP) is an inflammation of the lungs that occurs 48 hours or more after the start of hospitalization and was not incubated at admission [1].

Hospital-acquired pneumonia accounts for approximately 17% of all intensive care unit (ICU) infections in the world [2-5] and is responsible for over 50% of antibiotic consumption in these departments [6]. According to the European Centre for Disease Prevention and Control (ECDC) report, 97% of pneumonia episodes in ICU hospitalized patients are associated with intubation [7] and are associated with the risk of complications, including fatal ones, prolonged hospitalization and an increase in the average cost of treatment [8-11]. VAP is defined as the deterioration of the mechanical ventilation parameters after about 2 days of stable ventilation, resulting in the increase of positive end expiratory pressure (PEEP) by at least 3 cm H_2O and an increase in FiO_2 by at least 20%. In the diagnosis of VAP, a temperature above 38°C or below 36°C and the presence of leucocytosis (≤ 12,000) or leukopaenia (≥ 4000) are also taken into account. The definition characterizes a possible VAP if there is a purulent secretion in the bronchial tree and there is an increase in pathogenic microorganisms in microbiological tests [10]. It should be remembered that the diagnosis of pneumonia for epidemiological surveillance purposes is based on 3 criteria: clinical, laboratory (radiological and/or microbiological), and epidemiological [12]. However, there is still no gold standard for the diagnosis of HAP or VAP [1]. It is estimated that the costs of VAP treatment are among the highest of all nosocomial infections (according to American data they are 10,000-100,000 USD per patient) [13, 14] and are mainly associated with longer

periods of support ventilation and prolonged stay in the ICU and in the hospital [9]. VAP is the most common cause of nosocomial infections in the ICU [11]. In a Polish study conducted from 2007 to 2010, the incidence of VAP amounted to 18.2/1000 days of mechanical ventilation (MV) [15]. In another Polish single-centre study conducted from 2007 to 2016, the incidence of VAP was 15.2/1000 MV days [2]. However, in a multicentre study carried out in Poland as well, in 2013-2015 the incidence of VAP was 12/1000 MV days [16]. The study conducted in 2018-2019 reported an incidence of 9.7/1000 days of mechanical ventilation [17]. In Europe, the mean incidence of VAP as regards 11 European countries amounts to 9.5/1000 days of mechanical ventilation, varying from 2.3/1000 MV days (Luxemburg) to 20.1/1000 MV days (Belgium) [7]. The VAP incidence rate obtained from American surveillance data was lower than the one in Europe, amounting to 0.0-4.4/1000 MV days in 2012 [18]. Mortality due to VAP reaches 13%, as shown by European studies [9, 19]. A similar result of 13.6% was recorded in a Polish study [16]. A much lower percentage is given by a Canadian study in which the mortality rate was 5.8% [8]. This form of infection is also associated with an extended stay in the ICU by approx. 4-14 days [1, 3, 8, 20]. A Turkish study documented 4 times longer hospitalization in patients with VAP compared to patients without VAP [21]. VAP is classified as an undesirable event [22]. Considering all the consequences of this infection, effective preventive measures should be implemented to increase the safety of hospitalized patients. For this purpose, infection control is essential, one of the key goals of which should be the prevention of pneumonia associated with intubation [23]. The objective of this study is to familiarize the reader with the problems of VAP prevention, and the risk factors and nursing care for a mechanically ventilated patient.

REVIEW METHODS

The literature was selected through the use of the PubMed and Google Scholar databases. To find materials, the following keywords were used: VAP, ICU, risk factors, nursing care, and epidemiological surveillance. The publication was reviewed without any time limits. Several hundred positions were obtained, from which works on VAP issues in paediatric hospitals as well as works on VAP diagnostics and treatment were excluded. The guidelines for HAP/VAP of Polish and foreign and international scientific societies since 2005 were reviewed. As a result, the recommendations of the American Thoracic Society (ATS) and the Infectious Diseases Society of America (IDSA), Infectious Diseases Society of America and Society for Healthcare Epidemiology of America (IDSA/SHEA), European Centre for Disease Prevention and Control (ECDC), Association of Hospital Epidemiology, Hospital Infection Society, Polish Association of Epidemiological Nurses, Małopolska Association of Hospital Infection Committees and Teams, Health Services Executive (HSE) and Health Protection Surveillance Centre (HPSC) in Ireland, European Respiratory Society/European Society of Intensive Care Medicine/European Society of Clinical Microbiology and Infectious Diseases/Latin American Thoracic Association (ERS/ESICM/ESCMID/ALAT), National Healthcare Safety Network (NHNS) – 2022, The French Society of Anaesthesia and Intensive Care Medicine and the French Society of Intensive Care, National Antibiotic Protection Program (NPOA), and the Anaesthetic and Intensive Care Nursing Practice Working Group of the Polish Society of Anaesthesiology and Intensive Care Nurses (PTPiIO) were analysed and publications of Polish and foreign authors discussing the issues discussed. Work from the pandemic period was also included. The review was carried out in the period of January-July 2022.

RESULTS OF THE REVIEW

In the prevention of VAP, a multifaceted approach should be used, taking into account general preventive measures, such as: hygiene of staff hands, personal protective equipment, condition of the facility, and appropriate staffing of medical personnel [24, 25]. Specific methods include measures to prevent contamination of respiratory equipment and reduce the risk of oropharyngeal aspiration and gastrointestinal colonization [24, 25]. There are many risk factors for the development of VAP – endogenous, patient-related, and related to treatment and care [17, 26-29].

Patient-related VAP risk factors

Patient-related risk factors are not subject to modification; however, being aware of them should alert the staff to carefully observe and monitor patients for symptoms of VAP [29]. The most frequently mentioned types include multi-organ trauma, underlying disease (including diseases of the central nervous system with accompanying disturbances of consciousness, cardiovascular and respiratory diseases, sepsis, haemorrhage, shock) [26, 29], comorbidities (e.g. chronic obstructive pulmonary disease [COPD], diabetes, obesity, alcoholism) [29], old age [30], and being male [31, 32].

Detailed risk factors related to the patient and their interpretation are presented in Table 1.

Treatment-associated risk factors

Analysis of the literature makes it clear that there are multiple risk factors associated with treatment. In their guidelines regarding the course of action in HAP/VAP, the American Thoracic Society (ATS) and

Table 1. Patient-dependent risk factors for the development of VAP

Risk factor	Interpretation	Year of publication	First author of the publication
Trauma	increases risk: multi-organ trauma, fractures ($p < 0.001$)	2020	Kózka M [29]
	increases risk: multi-organ trauma ($p = 0.009$), head trauma ($p = 0.001$), thoracic injury ($p = 0.04$)	2018	Arumugan SK [30]
	increases risk	2018	Dananche C [32]
	increases risk (OR = 2.89)	2016	Koulenti D [57]
	increases risk	2016	Wałaszek M [26]
	increases risk	2014	Ranjan N [28]
Comorbidities	increase risk: diabetes ($p = 0.016$), obesity, alcoholism, COPD ($p < 0.001$)	2020	Kózka M [29]
	do not increase risk – COPD	2016	Koulenti D [57]
Underlying disease (reason for admission)	increases risk COVID-19 ($p = 0.0015$)	2021	Maes M [58]
	increases risk COVID-19 ($p = 0.015$) (OR = 3.24)	2021	Ippolito M [59]
	increases risk: haemorrhage, shock ($p < 0.001$)	2020	Kózka M [29]
	increases risk: sepsis, diseases of the central nervous system, endocrine system, respiratory system	2016	Wałaszek M [26]
Older age	increases risk ($p = 0.002$)	2018	Arugumam SK [30]
	does not increase risk in the population ≥ 45 y.o.	2016	Koulenti D [57]
	increases risk in cardiac surgery patients ($p < 0.01$)	2014	Sheng W [27]
Male gender	increases risk	2018	Dananché C [32]
	increases risk ($p = 0.004$)	2018	Kock K [31]
Disease severity	increases risk: APACHE II, SOFA ($p < 0.001$)	2021	Dongol S [36]
	increases risk: APACHE II above average ($p = 0.016$)	2018	Kock K [31]
	disease severity increases risk – higher ISS ($p = 0.001$), lower GCS ($p = 0.007$)	2018	Arumugam SK [30]

VAP – ventilator-associated pneumonia, OR – odds ratio, p – significance level, GCS – Glasgow Coma Scale, ISS – injury severity score, COPD – chronic obstructive pulmonary disease, APACHE II – Acute Physiology and Chronic Health Evaluation II, SOFA – sequential organ failure assessment score

the Infectious Diseases Society of America (IDSA) mention intubation and mechanical ventilation, aspiration, body position of the ventilated patient, enteral nutrition, and prevention of stress bleeding among the modifiable risk factors, i.e. those associated with treatment [33]. Care packages that include several interventions on modifiable risk factors may prove helpful [6]. They typically involve 3 to 5 evidence-based interventions that are more effective when used together. The most common procedures include the following: the use of sedation protocols and daily pauses in sedation, assessment of the possibility of breaks in ventilation and the possibility of extubation, raising the head of the bed by 30-45 degrees, oral care, and drainage of subglottic secretions [23, 24]. An important part of VAP prophylaxis is the procedure of pressure control in the cuff of the endotracheal or tracheotomy tube [17]. The interventions taken can be monitored and used as quality indicators in the context of epidemiological surveillance [23]. Różańska *et al.* [34] in a review study showed the effectiveness of the use of "bundlecare" in the prevention of VAP by comparing the incidence rates before the implementation of packages after implementation, regardless of the number and selection of interventions included in the composition. Analysis of the literature makes it clear that there are also other risk factors, such as the following: the number of nurses caring for patients in the ICU [35], the duration of hospitalization [21, 36], the duration of hospital stay in ICU [21, 31, 36], emergency surgery, perioperative blood transfusions [27], and pre-hospital bronchial intubation [37]. In the case of VAP risk factors, which are dependent on medical procedures, it seems obvious that preventive strategies to reduce the incidence rates should be implemented. Being aware of VAP risk factors may contribute to the improvement of the quality of care and effective prevention [23, 30, 38].

The treatment-related risk factors are presented in detail in Table 2.

Epidemiological surveillance of VAP

Effective HAI surveillance systems can reduce the risk of infection by as much as 55-70%. The most important elements of an effective infection control program include the presence of trained personnel, the monitoring of nosocomial infections, and the presence of effective infection prevention procedures [23]. In line with the 2009 recommendations of the

Table 2. Treatment-dependent risk factors for the development of VAP

Risk factor	Interpretation	Year of publication	First author of the publication
Duration of ICU hospitalization	increases risk (OR = 3.32)	2022	Pawlik J [17]
	increases risk ($p < 0.001$)	2021	Dongol S [36]
	increases risk ($p = 0.003$)	2018	Kock K [31]
	increases the risk (OR = 1.47)	2012	Alp E [21]
Duration of hospital stay	increases risk ($p < 0.001$)	2021	Dongol S [36]
	increases risk	2020	Kózka M [29]
	increases risk (OR = 3.11)	2012	Alp E [21]
Duration of mechanical ventilation	increases risk ($p < 0.001$)	2021	Dongol S [36]
	increases risk ($p = 0.001$)	2018	Kock K [31]
	increases risk if > 20 days ($p = 0.001$)	2016	Wałaszek M [26]
	increases risk if > 15 days ($p < 0.01$)	2014	Ranjan N [28]
	increases risk in cardiac surgery patients ($p < 0.01$)	2014	Sheng W [27]
Tracheostomy	increases risk (OR = 1.6)	2022	Pawlik J [17]
	no increases risk ($p = 0.047$)	2020	Kózka M [29]
	increases risk ($p < 0.001$)	2016	Wałaszek M [26]
Reintubation	increases risk (OR = 7.57)	2016	Gao F [56]
	increases risk ($p < 0.001$)	2016	Wałaszek M [26]
	increases risk in cardiac surgery patients ($p < 0.01$)	2014	Sheng W [27]
Pre-hospital intubation	increases risk: EBI after field intubation was associated with a nearly two-fold increase of early VAP, though not statistically significant (30% vs. 17%: $p = 0.09$)	2019	Padilla A [37]
Emergency surgery	increases risk in cardiac surgery patients ($p < 0.01$)	2014	Sheng W [27]
Antibiotics on admission	protective effect	2018	Dananche C [32]
Perioperative blood transfusions	increase risk in cardiac surgery patients ($p < 0.01$)	2014	Sheng W [27]
MDR (multi-drug resistant) bacteria	increases risk (OR = 2.73)	2022	Pawlik J [17]

VAP – ventilator-associated pneumonia, ICU – intensive care unit, p – significance level, OR – odds ratio

Council of the European Union on the methods and goals of implementing nosocomial infection control systems, it is recommended that certain types of infections be monitored and supplemented with structure and process indicators to evaluate the infection control measures implemented [39]. According to protocol 2.2 of the ECDC from 2017, surveillance in the ICU is to be carried out on the basis of structural, process, and outcome criteria. In order to conduct an epidemiological analysis of hospital-acquired pneumonia, the following parameters can be used:

Structural and process indicators:

- consumption of alcohol-based hand sanitizer – the amount of the agent in litres used in the previous year × 1000/the number of ICU patient-days in the previous year,
- staff-to-patient ratio – the sum of hours of registered nurses and nursing assistants in the ICU over a seven-day period × 100/the number of person-days in the course of 7 days 24 hours,
- pressure in the tracheal tube cuff – the number of days of intubation (days of patients with intubation) during which endotracheal cuff pressure was monitored and documented and maintained within the range of 20 to 30 cm H_2O at least twice a day × 100/the total number of intubation days observed,
- oral decontamination – the number of intubation days (days of patients with intubation), during which oral hygiene was conducted using antiseptics at least twice a day × 100/the total number of intubation days observed,
- patient position – the number of days of patients with intubation during which the patients were not supine × 100/the total number of intubation days observed.

Outcome indicators:

- incidence of pneumonia (PN): refers to the number of new cases of PN identified compared to the number of patients exposed (hospitalizations) in the period under study (incidence = number of PN/number of hospitalizations × 100),
- incidence (density) of PN: refers to the number of new cases of PN identified compared to the number of days of hospital stay in the period of time analysed (incidence = number of PN/number of person-days × 1000),

- incidence (density) of VAP/IAP: refers to the number of new cases of PN identified compared to the number of days with mechanical ventilation (MV) in the period under study (incidence = number of VAP/IAP/number of person-days of MV × 1000),
- ventilator utilization ratio (VUR): VUR = the number of person-days of hospitalization/the number of person-days with the invasive device [40].

The overall objective of surveillance is to reduce the incidence of VAP and to improve patient safety and quality of care. Surveillance systems based on a process including, for example, compliance with guidelines and recommendations, seem to be simpler than those based on results, which include epidemiological indicators. Variability as regards outcomes requires time and involves a large patient population; moreover, improvements at the process level may have a positive impact on the outcome, thereby motivating staff to improve the quality of care [38]. The 2016 Society for Healthcare Epidemiology of America position paper on the structure of the HAI control program emphasizes that in order to increase operational efficiency, the daily practice of HAI surveillance should be based on the targeted implementation of scientific evidence based on the following: engaging and explaining why the intervention is needed; education, i.e. providing evidence of effectiveness; and action, i.e. planning and implementing an intervention, e.g. through a package of actions and assessment of the effects of the action [41].

Mechanically ventilated patient nursing care

To ensure the safe care of a ventilated patient, it is recommended to develop and implement procedures to prevent the occurrence of VAP [24]. These include general prophylaxis procedures and specialized procedures aimed at preventing VAP. As part of general prophylaxis, the following are important: hand hygiene of the staff, use of personal protective equipment, patient isolation, and decontamination of medical equipment [25].

1. Hand hygiene of medical personnel. The hands of medical staff are considered the most important vector for the transmission of hospital-acquired infections [42], and at the same time, they are the simplest and most effective precaution against HAI. Meanwhile, according to research, compliance with hand hygiene procedures is believed to be < 50%. A study conducted in a group of doctors and medical students in a Polish hospital makes it clear that three-quarters of the respondents did not apply the technique of hand hygiene correctly. The study also pointed to poor familiarity with the 5 Moments for Hand Hygiene developed by the World Health Organization (WHO) [43]. The most common mistakes are insufficient washing time, no hand drying, and insufficient time of hand disinfection [44].
2. Personal protective equipment. Gloves should be replaced after performing the procedures for each patient, and their use cannot substitute the hand hygiene procedure [25]. The main purpose of gloves is to protect staff from potentially infectious material and patients from cross-contamination. In the prevention of HAIs, other elements of personal protection are also important, such as masks, goggles, and disposable gowns for tasks during which there is direct contact with potentially infectious material (e.g. oral toilet, open system tracheobronchial toilet, toilet after faecal contamination, etc.) [44]. It is important to remember to protect one's face during suction in the open system and when disconnecting closed breathing circuits [24].
3. Patient isolation – in the ICU, it is advisable to develop and implement the rules of standard isolation applicable to every single patient, regardless of whether an infection has been diagnosed or not. Standard isolation relies on the use of appropriate hand hygiene, limitation of unnecessary contact with the patients and their environment, and the application of disinfection for one's bench and equipment following use with a patient [25].
4. Decontamination of medical equipment. If possible, disposable equipment should be used. Reusable equipment should be dedicated to a specific patient, and if this is not possible, it should be decontaminated prior to use in other patients. It is of particular importance to decontaminate semi-critical equipment, i.e. equipment that comes into contact with mucous membranes. It should be free of microbes, but it may contain a small number of bacterial spores. This equipment should be subjected to a high level of sterilization or disinfection. In the case of VAP, it is respiratory therapy equipment: laryngoscopes, drains, and self-inflating bags. Laryngoscopes can be sterilized or subjected to high-level disinfection. The method for decontamination depends on the manufacturer's recommendations. The remaining equipment, such as laryngeal masks, face masks, and oesophageal/rectal temperature probes, if it is reusable, should be subjected to a high level of cleaning and disinfection [25]. Sterile water should be used to rinse reusable respiratory equipment [24]. Ventilators should be cleaned and disinfected according to the manufacturers' recommendations; external surfaces of the ventilator, including screens, should be disinfected once a day and after the patient is discharged. Pressure-measuring devices are very easily contaminated with pathogenic microorganisms; therefore, the cuffs should be assigned to a particular patient, and after the patient's discharge, they should be disinfected by immersion, and if

this is not possible, disinfected through wiping with a disinfectant [25]. It is essential to develop and implement procedures for medical equipment decontamination in the ICU [25].

Analysis of the guidelines of Polish and foreign scientific societies and numerous publications concerning the prevention of VAP allows us to determine priorities in nursing care. They include:

1. Patient's body position – it is recommended that the patient be nursed in a semirecumbent position with the head of the bed raised by approx. 30-45°, provided there are no contraindications. Maintaining this position is aimed at reducing the risk of aspiration of secretions or contents from the gastrointestinal tract [24, 25, 45]. It is also suggested by some that rotating beds be used, especially in patients who do not tolerate the semirecumbent position [24]. The prone position is not recommended [45].
2. Oral hygiene – through the administration of oral antiseptics, is aimed at reducing the oral flora in the event of micro-aspiration of secretions around the endotracheal tube cuff [6, 40]. After 48 hours of hospitalization, the composition of the oral flora is significantly changed, i.e. Gram-positive rods, usually dominant, are replaced by Gram-negative rods, commonly associated with VAP. They enter the lower respiratory tract as a result of aspiration of oropharyngeal and nasopharyngeal secretions around the cuff of the endotracheal tube. Hence, oral hygiene in mechanically ventilated patients is of great importance in preventing VAP [36]. Despite publications reporting a positive effect of chlorhexidine preparations on the reduction of VAP [48, 49], not all scientific societies recommend this procedure for routine use [1, 11]. The National Antibiotic Protection Program (NPOA) recommends the use of 2% chlorhexidine 2-4 times a day for oral hygiene in mechanically ventilated patients undergoing cardiac surgery; in other patients, it is recommended that the use of antiseptics containing chlorhexidine be considered [25]. According to the ECDC, chlorhexidine or povidone-iodine may be used [40]. Preparations with cetylpyridine and octenidine may also prove effective in the oral cavity, but alcohol-based rinses are not recommended because they dry the oral mucosa [22, 47].
3. Tracheobronchial toilet. Suction of secretions in intubated patients can be conducted using an open or closed system. According to NPOA recommendations, the application of a closed system is justified in the treatment of patients with infections which can be transmitted by air or airborne droplets, including influenza, tuberculosis, and SARS, because there is no advantage of the closed system over the open system in preventing VAP. The selection of a closed system may be determined by economic analysis [25]. Interesting results regarding the costs related to the selection of the suction system are provided by a Polish study – the daily cost of suction in a closed system in one patient is even half as much as in an open system [50]. In spite of the fact that there is no strong evidence suggesting the advantage of using the closed systemin in preventing VAP, it may be beneficial in reducing the exposure of healthcare workers to aerosolized respiratory secretions [22, 24]. The tracheal suction procedure is an aseptic procedure and requires sterile equipment. The procedure should be performed with the use of sterile gloves and sterile catheters. One catheter must not be used for aspiration of the nasopharynx and trachea. It is recommended that routine aspiration of secretions from the respiratory tract only performed when necessary. The endotracheal tube must not be rinsed with 0.9% NaCl solution to liquefy the secretion [22, 51]. An achievement in the care of the respiratory tract in mechanically ventilated patients is the use of endotracheal tubes with the possibility of suctioning secretions from the subglottic area. Suction can be carried out continuously or intermittently [22]. Polish researchers have proven that continuous subglottic suction reduces the overall incidence of VAP and early VAP, and also lengthens the time to VAP in ventilated patients [52, 53]. Despite the higher cost of specialized endotracheal tubes, global treatment costs are lower than when using traditional endotracheal tubes. The subglottic suction method is recommended by the Polish Society of Anaesthesiological and Intensive Care Nurses (PTPAiIO) [22]. It is also highlighted that the pressure in the endotracheal tube cuff should be monitored and kept at > 20 cm H_2O according to recommendations, to prevent the escape of secretions together with microbes from around the cuff of the tube and into the lower respiratory tract. Overly high pressure can cause a pressure ulcer in the trachea, and too little pressure will cause a leak in the respiratory system and allow for choking and micro-aspiration of secretions [22, 51].

   Physiotherapeutic procedures such as gravity positioning, vibration massage, percussion, and chest kinesiotherapy performed cyclically for at least half an hour contribute to better aeration of the lungs and evacuation of secretions, which has a positive effect on the patient's spirometric parameters [22].
4. Replacing the ventilator circuit. Daily replacement of the circuit does not reduce the frequency of VAP [24]; hence, many scientific societies recommend replacing them only in the event of contamination or damage [24, 25, 45]. Antibacterial filters are only recommended for patients with an airborne infection, according to NPOA recommendations [25].
5. Feeding the patient – enteral nutrition is considered a risk factor for the development of VAP, mainly due

to the increased risk of gastric aspiration. Parenteral nutrition is not without its complications either. It is associated with a higher risk of the development of intravascular infections as well as deformation of the intestinal villi structure, which may facilitate the translocation of intestinal microbes [33]. Enteral nutrition is recommended [45, 54]. French guidelines recommend starting feeding 48 h after admitting the patient to the ICU [55]. It should be remembered that orogastric probing should be used and that the patient of enteral nutrition should be placed in the supine position (30-45°) [25]. As per SHEA/IDSA guidelines, early parenteral nutrition is not recommended [45].

6. Daily assessment of the depth of sedation in terms of assessing the readiness for extubation, peptic ulcer prevention, and thrombophlebitis prophylaxis – these are medical interventions that also apply in the prevention of VAP [22].

It should be noted that prevention of complications related to ventilation, including VAP, is an interdisciplinary team task. All members of the therapeutic team should be involved in the implementation of individual elements of this process [22].

It should be mentioned that numerous attempts are being made to develop effective methods of preventing VAP through the implementation of several (most frequently 3-5) interventions at the same time, known as a bundle. It is not recommended that the number of interventions in the bundle exceed 5, because a greater number reduces the chance of complying with the procedures. Each hospital should establish priority intervention bundles to be implemented on the basis of the infection risk factors identified, assessment of the current epidemiological situation, the organizational ability to implement them, and economic analysis. The bundle implemented should be monitored in order to reach a compliance of 95% [23].

SUMMARY

Ventilator-associated pneumonia is the most complex and serious infection acquired in the ICU, which significantly worsens the prognosis, extends hospitalization time, and increases the cost of treatment. It is evident that there is a need to search for and implement effective preventive measures in the daily care of patients who require mechanical ventilation. Safe care of a mechanically ventilated patient requires extensive knowledge and experience of the personnel providing the care as well as efficient nosocomial infection surveillance. Being familiar with the risk factors for VAP, both the ones that depend on the patient and those that are associated with treatment, can help to take action aimed at limiting the frequency of occurrence of this form of infection. The prophylaxis is even more effective due to the implemented procedures, developed on the basis of evidence that takes into account the general principles of HAI prevention as well as infections related to specialist treatment. It is also essential to supervise their implementation to compare the level of compliance of the care provided with the procedures in force.

Disclosure

The authors declare no conflict of interest.

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