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Factors associated with duration of mechanical ventilation at Intensive Care Unit Dr. Soebandi: a retrospective study

Rahmawati Dimas Sumarlan [1], Baskoro Setioputro [1] *, Rismawan Adi Yunanto [1]

[1] Faculty of Nursing Universitas Jember, Jember, Indonesia

*Correspondence: Baskoro Setioputro. Address: Faculty of Nursing Universitas Jember, Jember, Indonesia. Email: baskoro_s.psik@unej.ac.id

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ABSTRACT

Introduction: Several factors cause the increase in the duration of mechanical ventilation. This study aims to analyze the relationship between initiating diagnostic factors, age, gender, comorbidities, and mechanical ventilation complications with the duration of mechanical ventilation in the Intensive Care Unit Dr. Soebandi Jember.

Methods: : This study used a quantitative correlative design with a retrospective approach from medical records. This study used purposive sampling to select samples from 414 total populations, obtaining 81 medical records that met the inclusion criteria. The duration of mechanical ventilation is the dependent variable, while the initiation diagnosis, age, gender, comorbidity, and complications are independent variables. Data were collected using a checklist compiled by the researcher. Data were analyzed using Chi-square and logistic regression.

Results: The results showed that there was a relationship between initiation diagnosis (p=0.000) and complication factors (p=0.000) with the duration of mechanical ventilation, while age (p=0.449), gender (p=0.632), and comorbidities (p=0.752) had no relationship with the duration of mechanical ventilation. Multivariate analysis showed that the initiation diagnosis factor was the most dominant factor associated with the duration of mechanical ventilation, with an odds ratio of 11.9 and statistically significant (p=0.000).

Conclusions: This study shows that the duration of mechanical ventilation is most dominantly associated with the diagnosis of ventilator initiation and ventilator complications.

Keywords: duration mechanical ventilation; mechanical ventilation

Introduction

Mechanical ventilation is crucial for patients in the ICU because it is a supportive tool for patients undergoing surgical procedures, patients in critical condition, or experiencing a severe respiratory injury (Estenssoro *et al.*, 2005). The use of mechanical ventilation is increasing along with the number of patients who need mechanical ventilation. For example, Herold *et al.* (2020) stated that the number of patients at high risk of requiring mechanical ventilation increased to 80% in 2020 due to the increasing incidence of patients with respiratory failure. Meanwhile, data from the Intensive Care Unit (ICU) Dr. Soebandi Jember also saw an increase in the use of ventilators in non-COVID ICU patients in 2020, more than 200 patients. They increased again in 2021 to 214 patients. This ventilator-associated increase also occurred in the duration of use. In 2020, the duration of ventilator use was recorded for 1 to 18 days but increased in 2021 to 29 days. Ideally, ICU patients use a ventilator for a short duration, which is about 24 hours to 21 days (Liu *et al.*, 2019).

However, several factors can cause patients to take longer to use a ventilator (Ghauri Sanniya Khan *et al.*, 2019). According to various studies, the prolonged use of mechanical ventilation is caused by several reasons, one of which is the inability of patients to recover quickly

due to their complex illness, coupled with a history of previous illnesses suffered by patients before being admitted to the ICU (Bice and Carson, 2017). This is also supported by several other studies, which state that the diagnosis of initiating patients using a ventilator can be a factor that causes the duration of ventilator use to vary (Figueroa-Casas *et al.*, 2014). Prolonged mechanical ventilation is also exacerbated by increasing age, where the elderly are more at risk of using a ventilator for longer.

Long duration of mechanical ventilation use can lead to problems or illnesses in the ICU or what can be called Ventilator-Associated Events (VAE), such as Ventilator Associated Pneumonia (VAP), Barotrauma, pulmonary edema, cell damage, and necrosis. VAE can also increase if the patient has comorbidities (Al Enezi *et al.*, 2018; Liu *et al.*, 2019). Another study added that prolonged duration of mechanical ventilation use could also lead to infection, Post-Extubation Respiratory Failure (PERF) and reintubation, and even risk for ICU readmission. Complications in patients who experience prolonged mechanical ventilation (PMV) can cause other problems, such as increasing ICU length of stay, increasing treatment costs, and increasing ICU patient mortality (Esteban *et al.*, 2002; Chang *et al.*, 2018).

In the various studies mentioned above, data were obtained that several reasons were suspected to be related to the duration of mechanical ventilation. However, no studies discuss what factors are related and how strong this relationship is with the duration of mechanical ventilation in Indonesia. However, early identification of factors related to the duration of mechanical ventilation in Indonesia is essential for nurses to make plans while managing patients with various characteristics and diagnoses. Nurses also need to predict the length of mechanical ventilation use and collaborate with other health workers to determine mechanical ventilation weaning strategies, which differ between ventilator weaning strategies and patients who use ventilators for short and long periods (Huang *et al.*, 2014). In conclusion, the present study summarized the most significant factors related to the duration of mechanical ventilation, including the initiation diagnoses of mechanical ventilation, age, gender, comorbidities, and patient complications. This study aim is to examine the relationship between initiating diagnoses, age, gender, comorbidities, and complications on the duration of mechanical ventilation.

Table 1 Characteristics of research respondents (N = 81)

Characteristics	N	%
Initiation diagnoses		
Medical	24	29.6
Surgical	57	70.4
Age		
18-59 years	67	82.7
> 60 years	14	17.3
Gender		
Male	60	74.1
Female	21	25.9
Comorbidity		
None	51	63
With comorbidities	30	37
Complication		
None	40	49.3
With complications	41	50.7

Materials and Methods

Study Design

This study was a correlation design with a retrospective approach to examine the relationship between initiating diagnoses, age, gender, comorbidities, and complications on the duration of mechanical ventilation.

Place, Time, Population, and Sample

This research was conducted in the intensive care unit (ICU) RSD Dr. Soebandi Jember. This study was conducted from October 2021 to May 2022. The population of patients treated in the ICU during April 2020 - December 2021 was 414 patients. Our team determined the medical records that will be used as research respondents by purposive sampling technique. We set the inclusion criteria, among others: (1) non-COVID patients treated at Dr. RSD. Soebandi Jember from April 2020 to December 2021; (2) over 18 years old; (3) use the ventilator more than 24 hours. Samples that met the criteria obtained as many as 81 medical records.

Instrument and Data Collection

We used structural checklist to identify mechanical ventilation initiation diagnosis, age, gender, comorbidities, mechanical ventilation's complications, and duration of mechanical ventilation. We searched the data in the medical record room of Dr. Soebandi Jember. The head of the medical record room looked for the medical record number required according to the inclusion criteria. Researchers recorded the variables needed for research (name, age, gender, initiator diagnosis of ventilator installation, past medical history, patient complications). Researchers recorded duration of patient's use of a ventilator

Table 2 Chi-square analysis of initiation diagnoses, age, gender, comorbidities, and complications with the duration of mechanical ventilation

		Duration of mechanical ventilation				p-value
		1-7 days		> 7 days		
		n	%	n	%	
Initiation diagnoses	Medical	9	14.8	15	75	0.000
	Surgical	52	85.2	5	25	
		Duration of mechanical ventilation				**p-value**
		1-7 days		**> 7 days**		
		n	**%**	**n**	**%**	
Age	18-59 years	49	80.3	18	90	0.449
	> 60 years	12	19.7	2	10	
		Duration of mechanical ventilation				**p-value**
		1-7 days		**> 7 days**		
		n	**%**	**n**	**%**	
Gender	Male	46	75.4	14	70	0.632
	Female	15	24.6	6	30	
		Duration of mechanical ventilation				**p-value**
		1-7 days		**> 7 days**		
		n	**%**	**n**	**%**	
Comorbidity	None	32	63.9	12	60	0.752
	With comorbidities	22	36.1	8	40	
		Duration of mechanical ventilation				**p-value**
		1-7 days		**> 7 days**		
		n	**%**	**n**	**%**	
Complication	None	37	60.7	3	15	0.000
	With Complications	24	39.6	17	85	

Data Analysis

We used bivariate and multivariate analysis for several variables that were obtained. Chi-square was used to see the relationship between the independent variables (diagnose initiation, age, gender, comorbidities, and mechanical ventilation's complications) and the dependent variable (duration of mechanical ventilation). Relationship analysis was said to be significantly related if the p-value<0.05. This study used a 2x2 table, so cells with an expected value of <5 are a maximum 20% of the number of cells (continuity correction). If the expected value did not meet the Chi-square requirement, Fisher's exact test would be used as an alternative. Logistic regression was used to see which variable has the most substantial relationship. Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 16.

Ethical Considerations

This study was approved by the Health Research Ethics Committee, Faculty of Nursing, University of Jember with an Ethical Approval Certificate Reg. Number. 037/UN225.1.14/KEPK/2022.

Results

During this study period, 414 patients over 18 years who were hospitalized and underwent mechanical ventilation over 24 hours were enrolled, and 81 medical records met the study inclusion criteria; 70.4% of the 81 medical records in this study were surgical. Most patients are in the age range of 18-59 years. Most of the patients have a male gender (74.1%). Most patients (63%) had no comorbidity in the comorbidities variable. The difference in the percentage between patients who experienced complications after using the mechanical ventilation (50.7%) and patients who did not experience complications was not too significant (49.3%) (Table 1).

Patients who used mechanical ventilation for 1-7 days mostly came from surgical diagnosis (85.2%), while 75% of patients with medical diagnosis used mechanical ventilation for > 7 days. The bivariate analysis results in Table 2 concluded a significant relationship between initiation diagnosis with the duration of mechanical ventilation, as indicated by the p-value of p=0.000.

Patients who used mechanical ventilation for 1-7 days mostly came from the age range 18-59 years (80.3%), as well as patients who used mechanical ventilation for >7 days dominated by age > 60 years (90%). The bivariate analysis results in Table 2 obtained p=0.449. There is no significant relationship between the age factor and the duration of mechanical ventilation.

Patients who used mechanical ventilation for 1-7 days mostly came from the male gender (75.4%), as well as patients who used mechanical ventilation for >7 days were also dominated by the male gender (70%). The bivariate analysis results in Table 2 obtained p=0.632. There is no significant relationship between the gender factor and the duration of mechanical ventilation.

Patients who used mechanical ventilation for 1-7 days were dominated by patients who did not have a comorbidity (63.9%), as well as patients who used mechanical ventilation for >7 days were also dominated by patients who had comorbidities (60%). The bivariate

Table 3 Full model bivariate selection

Variables	p-value
Initiation diagnoses	0.000
Age	0.449
Gender	0.632
Comorbidity	0.752
Complication	0.000

analysis results in Table 2 obtained p=0.449. There is no significant relationship between the comorbidities factor and the duration of mechanical ventilation.

Patients who used mechanical ventilation for 1-7 days were dominated by patients who had no complications (60.7%), while 85% of patients who had complications used mechanical ventilation for >7 days. The bivariate analysis results in Table 2 concluded a significant relationship between complications with the duration of mechanical ventilation, as indicated by the p-value 0.000.

Table 3 shows that the bivariate analysis results have two variables related to the duration of mechanical ventilation: the initiation diagnosis and mechanical ventilation complications. Furthermore, the multivariate analysis used logistic regression to determine which variables were most related to the duration of mechanical ventilation.

Table 4 shows the final results of the logistic regression analysis, which shows that the initial diagnosis is the most related factor to the duration of mechanical ventilation with OR = 11.9 (CI 95% = 3.3 – 43.4) compared to the complication factor (OR = 4,8; CI 95% = 1,1 - 21.2).

In conclusion, patients with medical diagnoses were 11.9 times more likely to have a mechanical ventilation duration of more than seven days than patients with the surgical diagnosis.

Discussions

Relationship between Initiation Diagnoses and the Duration of Mechanical Ventilation

Based on the results of bivariate analysis using Chi-square, the p-value of 0.000 <0.05 was obtained. In conclusion, there is a relationship between the initiation diagnoses and the duration of mechanical ventilation in the ICU Dr. Soebandi Jember. There are a few previous studies stating that the initial diagnosis of mechanical ventilation could be a factor causing prolonged duration mechanical ventilation (Estenssoro *et al.*, 2005; Clark, Inocencio and Lettieri, 2018). A study by Saleha *et al.* (2012) states that the majority of surgical patients (98%) use mechanical ventilation for 1-5 days. This differs from patients with a medical or non-surgical diagnosis, where most patients with a medical diagnosis use a ventilator for more than seven days.

The initial diagnosis of mechanical ventilation is a patient's current condition that underlies the installation of mechanical ventilation. According to the Acute Physiology and Chronic Health Evaluation (APACHE) IV, last updated in 2006, the underlying diagnoses of patients admitted to the ICU are divided into non-surgical and surgical diagnosis (Zimmerman *et al.*, 2006).

The difference in the duration of mechanical ventilation is caused by differences in diagnoses, namely medical and surgical diagnoses (Saleha *et al.*, 2012). Medical diagnoses of the respiratory system can exacerbate prolonged duration of mechanical ventilation, as in ARF and COPD. This prolonged use is due to decreased patient condition, which can be caused by impaired coordination of the central nervous system with respiratory muscles, leading to hypoxemia. Clinical condition, cause, and the severity of the disease can adjust mechanical ventilation use and duration in patients (Shebl, *et al.*, 2022).

We assume that the factors that cause the initiation diagnoses are related to the duration of mechanical ventilation from differences between surgical and medical diagnoses. The severity of the disease and condition decreases, causing patients with a medical diagnosis to have an average duration of >7 days. This condition contrasts with surgical patients where the surgical procedure causes them to be on mechanical ventilation

Relationship between Age and the Duration of Mechanical Ventilation

Based on the bivariate analysis results using Chi-square, p-value 0.321 > 0.05, there is no relationship between age and duration of mechanical ventilation in the ICU RSD Dr. Soebandi Jember. Previous studies show that there is indeed a relationship between age and duration of ventilator use. Previous study from Nurhasty, Nurachmah and Maria. (2020) stated that patients over 60 years used mechanical ventilation for two to three days longer than the average use of

Table 4 Final analysis logistic regression

Variables	S.E	Wald	Sig	Exp (B)	95% C.I	
					Lower	Upper
Initiation diagnoses	0.657	14.289	0.000	11.980	3.306	43.416
Complication	0.750	4.464	0.035	4.879	1.122	21.227

mechanical ventilation. In addition, patients over 65 years use mechanical ventilation longer than patients under 65 years (Feng *et al.*, 2009),

However, different opinions occurred from other studies. For example, a previous study by Mori *et al.* (2020) said there was no relationship between age and duration of mechanical ventilation. Similar statements come from the study by Hira and Mittal (2006) and Bruno *et al.* (2022) which said there was no significant difference between the duration of mechanical ventilation and age.

Age is the time a living thing began to exist or was born (Wardani, 2012). Wheeler (2017) says age is divided into productive age from 18 to 59 years, and elderly age, 60 years and over. Several things can cause age-related duration of mechanical ventilation. Clearly, age affects physiological factors. Environmental and genetic factors also provide opportunities for accumulating diseases. Therefore, age affects acute and chronic organ failure. Which can cause complications (Wu *et al.*, 2019). This complication causes the duration of mechanical ventilation to increase. The alveoli of the elderly above 65 years are more easily deformed and tend to be loose. The strength of the diaphragm muscle also decreases, which causes muscle atrophy at this age, so the risk of respiratory failure is also greater. This respiratory failure can lead to an increase the duration of mechanical ventilation than it should (Frengley *et al.*, 2014).

However, other studies said the age factor is not independent, so there is no relationship between age and duration. Younger patients can have more chronic diseases than older patients. Other factors such as disease severity, quality of life, and activity daily living are additional factors and more considered at this time (Mori *et al.*, 2020). A similar statement comes from Frengley *et al.* (2014), that physiological conditions, especially in the respiratory system, can be a significant determinant of the duration of mechanical ventilation.

We argue that there is no relationship between the age factor and the duration of mechanical ventilation could occur because age is not an independent factor. Younger patients can have more chronic and complex diseases than older patients. Older patients may have better physiological conditions due to suitable daily living activities, fulfilled quality of life, and less severe disease severity compared to younger ages.

Relationship between Gender and the Duration of Mechanical Ventilation

Based on the bivariate analysis results using Chi-square, p-value 0.632 > 0.05, there is no relationship between gender and duration of mechanical ventilation in the ICU RSD Dr. Soebandi Jember. Several studies said that gender is one of the variables associated with the duration of mechanical ventilation. Mori *et al.* (2020) said that 54% of male patients who underwent mechanical ventilation also experienced a prolonged duration of mechanical ventilation and even experienced difficulties during the extubation process. Study from Feng *et al.* (2009) said differently, that there was no relationship between age and duration of mechanical ventilation. Other studies reported that gender was not an independent factor in determining the duration of mechanical ventilation (Roushdy, Abdel-Ghaffar and Saleh, 2018).

Gender is a biological difference between men and women. Gender is often associated as one of the factors associated that increased ICU stay, mortality, and duration of mechanical ventilation use. This increase happens because of other factors that may accompany this factor, such as daily living habits between men and women, such as smoking, unhealthy living habits, lack of activity, and comorbidities. These factors can lead to a gender-related relationship with the duration of ventilation (Mori *et al.*, 2020).

Actually, the relationship between gender and duration of mechanical ventilation has not been well-studied, and some studies said that many biases could occur if only looking at the gender factor. Previous studies explained that there is no relationship between gender and the duration of mechanical ventilation because gender did not determine the severity of the disease, although Mori *et al.* (2020) mentioned that male patients are at risk of using mechanical ventilation longer than women because they tend to have smoking habits, low Activity Daily Living, and comorbidities such as heart or lung disease. There is no difference in daily activities between men and women because the number of women who have inadequate living habits and have comorbidities is also high (Hira and Mittal, 2006).

We argue that the fact that there is no relationship between gender and the duration of mechanical ventilation could be because gender is not an independent factor. Other factors such as their daily living habits, the severity of their congenital disease, or differences in life expectancy could cause a longer

duration of mechanical ventilation in female or male patients.

Relationship between Comorbidities and the Duration of Mechanical Ventilation

Based on the bivariate analysis results using Chi-square, p-value 0.752 > 0.05, there is no relationship between comorbidities and duration of mechanical ventilation in the ICU RSD Dr. Soebandi Jember. Previous study from Mori *et al.* (2020) stated that 54.5% of patients who underwent mechanical ventilation have comorbidities. The patient's comorbidities included diabetes mellitus, heart disease, COPD, and kidney failure. Other studies also said that patients with comorbidities (acute kidney disorders, chronic liver disease, COPD, congestive heart failure, diabetes mellitus, myocardial infarction, and cancer) contain prolonged mechanical ventilation until 28 days (Lee and Cho, 2020). However, there is slightly different result from Hira and Mittal (2006), which stated that there was no significant relationship between comorbidities and duration of mechanical ventilation.

Comorbidities are a history of physical and psychological diseases in patients (diabetes mellitus, hypertension, asthma, stroke). Increasing age can have a variety of disease histories and can increase the risk of prolonged mechanical ventilation. In addition, respiratory comorbidities can prolong the duration of mechanical ventilation, such as COPD, asthma, and bronchitis. Comorbidity that is not related to the respiratory system was reported to have no significant relationship with the increase in the duration of mechanical ventilation (Lim *et al.*, 2022)

We argue that there is no relationship between comorbidities and the duration of mechanical ventilation lies in data limitations. Medical records data in ICU Dr. Soebandi only listed two medical histories, hypertension and diabetes mellitus. This finding collides with the previous studies mentioned above, which mapped various patient comorbidities. This study also showed that the initiation diagnosis did not come from the patient's medical record but primarily due to a post-traffic accident that did not have a history of previous illness. Based on the data of this study, it was also found that most of the patients who used ventilators for 1-7 days or >7 days had no comorbidity.

Relationship between Mechanical Ventilation's Complications and the Duration of Mechanical Ventilation

Based on the results of bivariate analysis using Chi-square, the p-value of 0.000 <0.05 was obtained. In conclusion, there is a relationship between the mechanical ventilation's complication and the duration of mechanical ventilation in the ICU Dr. Soebandi Jember.

Patients' complications can increase the duration of mechanical ventilation more than patients without complications. This increase has been investigated in previous study by Chang *et al.* (2018) which said ICU patients with septic shock and sepsis complications increased mechanical ventilation's duration by 21 days. Research conducted by Tobin (2013) stated that 20-50% of ICU patients, especially those who underwent mechanical ventilation, have one or more complications with a mortality percentage of 20-50%, and can increase with increasing duration of mechanical ventilation. Another study also stated that patients who experience complications while undergoing a mechanical ventilation could increase their mortality rate by ten times (Peña-López *et al.*, 2018).

Complications after using a mechanical ventilation are calculated 48 hours after the patient underwent mechanical ventilation. These complications include septic shock, pneumonia, cardiac output instability, splanchnic hypoperfusion, hypoalbumin, hypoxemia, hypercapnia, alkalemia, hypokalemia, hypomagnesemia, hypocalcemia, and changes in urine output. Things that cause a relationship between complications and the duration of mechanical ventilation because of the installation of the ventilator equipment are such as Positive Pressure Ventilation (PPV), endotracheal or tracheostomy tube, or when the patient is connected to the mechanical ventilation. (Udi *et al.*, 2021).

We believe there is a relationship between complications and the duration of mechanical ventilation because most patients who underwent mechanical ventilation with a duration more than seven days experience complications. This is different from patients who underwent a mechanical ventilation for 1-7 days who did not experience complications.

The most Related Variables to the Duration of Mechanical Ventilation

The results of the bivariate analysis have two variables related to the duration of mechanical ventilation, the initiation diagnoses variable and mechanical ventilation complications. The final results of the logistic regression can be seen, that the initiating diagnostic factor is the most related factor to the duration of mechanical ventilation with OR = 11.9 (CI 95% = 3.3 – 43.4) compared to the complication factor (OR = 4.8; CI 95% = 1.1 - 21.2).

In conclusion, patients with medical diagnoses were 11.9 times more likely to have a mechanical ventilation duration of more than seven days compared to patients with postoperative diagnoses. Previous study by Clark, Inocencio and Lettieri (2018) said that the duration of mechanical ventilation depended on the initial diagnosis. This may be due to differences in surgical and medical diagnoses. A report by Saleha *et al.* (2012) stated that the majority of surgical patients (98%) underwent mechanical ventilation for 1-5 days. This duration differs from patients with medical diagnoses, where most patients use mechanical ventilation for more than seven days. Factors other than the two factors studied, such as BMI, pre-operative, reintubation, activity daily living, and differences in the weaning process may be factors that can relate to the duration of mechanical ventilation (Muzaffar *et al.*, 2017). Another study also identified several independent predictors related to patients' demographics (advanced age and gender), health status (COPD, elevated heart rate, low ejection fraction, and kidney dysfunction), and surgery-related incidents (emergency and redo surgeries as well as the need of blood transfusion) (Ghauri Sanniya Khan *et al.*, 2019).
We argued that the initial diagnosis of mechanical ventilation is still an independent factor related to the duration of mechanical ventilation. These two factors can stand alone and can still be related to the duration of the ventilator.

Conclusions

This study's main finding showed a relationship between initiation diagnosis and complications with the duration of mechanical ventilation in the ICU Dr. Soebandi. There is no relationship between age, gender, and comorbidity factors with the duration of mechanical ventilation in the ICU Dr. Soebandi. The initiation diagnosis was the biggest factor related to the duration of mechanical ventilation in the ICU Dr. Soebandi. Finally, further research is needed to develop other factors, increase the sample, and readjust the inclusion and exclusion criteria that may relate to the duration of mechanical ventilation.

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Conflict of Interest

This research does not concern any commercial product

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