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The Effect of Ventilator Circuit Change every Five Days on the Occurrence of Ventilator-Associated Pneumonia among Critically Ill Patients

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1.ABSTRACT

Background: Ventilator-associated pneumonia (VAP) has a major impact on patients' outcomes, making it an important concept to understand for the health care team working with critically ill patients. It is a frequent complication of mechanical ventilation with a high mortality rate. Bacterial colonization of the ventilator circuits is one of the main sources of pathogens causing VAP in mechanically ventilated patients. Changing the ventilator circuits every five days may reduce the incidence of VAP among those patients. **Aim:** This study aimed to investigate the effect of ventilator circuit change every five days on the occurrence of VAP among critically ill patients. Method: A quasi-experimental design was used to conduct this study in the emergency surgical intensive care units of the Emergency Hospital at Mansoura University. A sample of 94 patients was randomly assigned to the intervention group (n = 47) and the control group (n = 47). The intervention group received 5 day ventilator circuit change and the control group received routine change. Ventilator-associated pneumonia assessment tool was used to collect data for this study. **Results:** The findings showed a reduction in the occurrence of VAP among patients with 5 day ventilator circuit change (P <0.001). **Conclusion:** Changing the ventilator circuits every 5 days is a safe practice and can significantly reduce the occurrence of VAP among critically ill patients. **Recommendations:** Critical care nurses should incorporate the ventilator circuit change every 5 days into their practices to reduce the occurrence of VAP and achieve good patients' outcomes. Large scale studies are needed to enrich the evidence related to mechanically ventilated patients' care.

Keywords: *Critically ill patients, Ventilator-associated pneumonia, Ventilator circuit change*

2.Introduction:

Ventilator-associated pneumonia has a major effect on patient outcome, making it an important concept for the health care team working with critically ill patients (CIPs) to understand **(Mittal & Madan, 2020)**. It is regarded to be a leading cause of mortality and morbidity among CIPs **(Terragni et al., 2020)**. Ventilator-associated pneumonia can make it difficult for patients to wean off the ventilator and keep them in the hospital longer, which puts a tremendous financial burden on patients and heavy demand on medical resources **(D. Wu, Wu, Zhang, & Zhong, 2019)**.

Despite advances in VAP diagnostic tools and treatment, it is still regarded as a common cause of intensive care unit (ICU) morbidity and mortality **(Othman & Abdelazim, 2017)**. A systematic review conducted by **Kharel, Bist, and Mishra (2021)** to analyze the VAP among ICU patients in the World Health Organization (WHO) Southeast Asian region showed that its incidence varied significantly by country, from 0.2% to 11.6%. The medical ICU in India reported the highest VAP prevalence rate, while the palliative care in South Korea recorded the lowest percentage.

In Egypt, analysis of VAP was done in some Egyptian University Hospitals. A study conducted by **Azzab, El-Sokkary, Tawfeek, and Gebriel (2016)** investigated multidrug-resistant bacteria among patients with VAP in an emergency ICU at Zagazig University Hospitals and reported that the incidences of VAP per 1,000 ventilator days was 48.8. **Othman and Abdelazim (2017)** studied the prevalence and complications of VAP in adult ICU at Cairo University Hospitals and found the incidence rate of VAP was 35.4 % in their study. While, **Elkolaly, Bahr, El-Shafey, Basuoni, and Elber (2019)** found the VAP prevalence among patients receiving mechanical ventilation (MV) in Tanta University Hospitals was significant (38.4%).

The pathogenesis of VAP is influenced by bacterial colonization of the upper

respiratory tract and gastrointestinal system, as well as aspiration of contaminated secretions into the lower respiratory tract. A patient receiving MV can develop VAP when bacteria colonize their lung parenchyma or lower respiratory tract. When colonized bacteria are inhaled, the vigorous host reaction may occur, resulting in VAP **(Osti, Wosti, Pandey, & Zhao, 2017)**.

Bacterial colonization of the ventilator circuits is one of the main sources of pathogens causing VAP in mechanically ventilated patients **(Elkammoshi, Ashur, El Magrahi, Abdulatif, & Almarouq, 2021)**. Pathogen bacteria, particularly those from the patient's secretions, are present in the ventilator circuits. After day three, there is bacterial colony growth in the ventilator circuits, and day seven shows a significant increase in colonies. Thus, it has been shown that there was a connection between colonization of bacteria in the ventilator circuits and the occurrence of VAP **(Perdhana, Utariani, Semedi, & Setiawan, 2016)**.

The maximum duration for which ventilator circuits may be used safely is unknown according to our clinical experience in Egyptian hospitals. Some studies compared the ventilator circuit change (VCC) at different intervals (every 1, 2, 3 or 7 days) and showed that frequent change increases the risk of VAP, but that when the circuit change was prolonged, the incidence of VAP decreased **(Chu et al., 2015; Hsieh et al., 2010; Liu, Ding, & Wang, 2017; Samransamruajkit et al., 2010)**. The appropriate frequency of VCC concerning the VAP occurrence has been rarely investigated in adults. To the best of our knowledge, the current study is the first investigation in Egypt that addressed the impact of changing the ventilator circuits every five days on the occurrence of VAP among CIPs.

Research Aim

This study aimed to investigate the effect of ventilator circuit change every five days on the occurrence of ventilator-associated pneumonia among critically ill patients.

Research Hypothesis

Critically ill patients who receive VCC every five days will have a decreased occurrence of VAP than those who receive routine VCC.

3.Method

3.1Research Design

A quasi-experimental research design was used in this study. It gives critical opportunities to generate data on cause-effect relationships without the use of randomization **(Polit & Beck, 2018)**.

3.2Setting

This study was conducted in three surgical ICUs at Mansoura Emergency Hospital (surgical 1, surgical 2, & surgical 3). Each unit has a capacity of 10 beds. Surgical 1 unit is separated into two sections; one of them is the isolation section, and each part has a capacity of 5 beds. The three surgical ICUs provide care to patients with surgical and neurological problems, and multiple trauma injuries. These units are well equipped with advanced technology and the manpower needed for CIPs' care.

3.3Sample

A convenience sample of 94 adult CIPs who were recently admitted to the above-mentioned settings throughout the study period were recruited in the current investigation based on the following criteria: Adult patients aged more than or equal 18 years and newly admitted patients who were intubated within 24 hours of ICU admission. Patients who were extubated, died or diagnosed with VAP within five days of their ICU admission or who had VCC before the planned date (5^{th} day) were excluded. Patients with non-invasive ventilators as bi-level positive airway pressure or continuous positive airway pressure were also excluded.

Sample size calculation

The power analysis and sample size software determined the sample size. An Egyptian study conducted by **Elkolaly et al. (2019)** reported that the incidence of VAP was 38.4% among the intubated patients and that 5-day VCC versus the routine change will

reduce the occurrence of VAP from 38.4% to around 19.2%. Accordingly, 47 patients in the intervention group (5-day VCC) and 47 in the control group (routine VCC) achieved 90% power to detect a difference between the group proportions of - 0.30. The proportion in the intervention group was assumed to be 0.50 under the null hypothesis and 0.20 under the alternative hypothesis. The proportion of the control group was 0.50. The statistical test used was the one-sided fisher's exact test (FET). The significance level of the test was targeted at 0.050 (the actual $\alpha = 0.03$).

3.4Data Collection Tool

Data were collected using the "ventilator-associated pneumonia assessment tool". This tool consisted of three parts: part I and II were developed by the Primary Investigator (PI) based upon relevant literature **(Aysha, El-Din, Attia, & Akab, 2016; Galal, Youssef, & Ibrahiem, 2016)**. While, part III included the modified clinical pulmonary infection score (CPIS) for the clinical diagnosis of VAP **(Pugin et al., 1991)**.

Part I: Participants' Socio-Demographic Characteristics and Health-Related Data

This part was used to collect data about participants' socio-demographic characteristics including age, gender, occupation, smoking habits, and level of education. It also covered participants' health-relevant data including the date of admission to the ICU, medical diagnosis, comorbidity, the feeding method, the level of consciousness based on Full Outline of Unresponsiveness (FOUR) score, date of discharge or death, and the date of extubation or VAP diagnosis.

Part II: Ventilator Modalities Data

This part covered participants' ventilator modalities data including the initiation date of intubation, the method of ventilation, ventilator mode, duration on MV, and the frequency of the VCC.

Part III: Ventilator-Associated Pneumonia Diagnostic Criteria

This part included the modified CPIS for the clinical diagnosis of VAP. The initial CPIS was designed by **Pugin et al. (1991)**, and composed of six clinical variables; the participant's body temperature, WBC count, amount and purulence of tracheal secretions, oxygenation (PaO_2:FiO_2 ratio), chest radiography findings (no infiltrates, diffused infiltrates), and culture of tracheal aspirate, each worth 0-2 points. The total points range from 0 to 12. A score of more than 6 is linked with pneumonia. This scale showed a good interrelated reliability ($r = 0.84$, $p < 0.0001$).

In the present study, the modified CPIS was adopted but without the culture section. This is because the tracheal aspirate culture was rarely available in the ICU and there was a delay in its result from 24 to 48 hours. Similarly, some previous studies used the CPIS score without the culture section (**Chen et al., 2018; Jackson & Owens, 2019; Moustafa, Tantawey, El-Soussi, & Ramadan, 2016**). The total points range from 0 to 10. A score of more than 5 is considered indicative of pneumonia.

3.5Validity and Reliability

The content validity of part 1 and part II of the tool was tested by seven experts from the Nursing and Medical fields. According to their opinions, modifications were done, such as using the FOUR score instead of Glasgow coma score in determining the level of consciousness and adding combined feeding methods besides the enteral and parenteral methods. The reliability of the CPIS (without the culture section) was tested using Cronbach's alpha test and the result was 0.876, which denotes a highly reliable scale.

3.6Pilot Study

A pilot study was carried out on 10% of the total sample (nine patients) before starting the data collection process to test the applicability, clarity, and feasibility of the data collection tool. Those patients were excluded from the main study investigation.

3.7Ethical Considerations

The Research Ethics Committee of Faculty of Nursing, Mansoura University granted ethical approval for this study (No. P.0240). Permission was obtained from the director of the hospital after explaining the aim of the study. Informed consent was obtained

from the patients' next of kin after explaining the nature, benefits, and risks of the study. Patients' next of kin were informed that participation in the study was voluntary and that they had the right to accept or refuse to take part in this investigation. Moreover, they were assured about the confidentiality of the patient's personal information and their right to withdraw from the study at any stage without responsibility.

3.8Data Collection Process

Data were collected by the PI between August 2020 and April 2021. Permission was obtained from the study setting to conduct this investigation after explaining the nature of the study. The PI interviewed patients' families on the first day of the patient's admission and explained to them the nature of the study. The data collection process was started once the next of kin agreed to allow the patient to participate in the study.

Intervention

The PI screened all patients on the first day of ICU admission to confirm that they were free from the exclusion criteria. The eligible patients were divided equally into the intervention group and the control group. Random assignment of the patients is done by the envelope method. The PI marked part of the ventilator circuits with the name of the recruited patient and the date of his admission with adhesive tape, and checked it continuously.

For the Intervention Group

The ventilator circuits was changed every 5 days according to the practice of the hospital as follows: Cleanly placing the new circuit in a position allowing quick connection to the ventilator and then to the patient, disconnecting the old circuit from the ventilator then from the patient and connecting the new one, assuring proper function of the new circuit, and continuously monitoring the saturation of haemoglobin by oxygen, heart rate, and the colour of the patient during the VCC. After changing the ventilator circuit, the patient and the circuit were checked for air leaks, incomplete circuit connection, or other problems.

For the Control Group

There was no specific routine for changing the ventilator circuits in the study setting. It was left unchanged until visibly soiled or malfunctioning occur.

Outcome Evaluation

The recruited patients were followed up for VAP diagnosis on the 3rd, 5th, 7th days and so on during their stay on MV using the modified CPIS. Patients with scores more than five were categorized as having VAP, while those who had scores less than five were considered VAP- free.

3.9Data Analysis

After completing data collection, it was analysed using the Statistical Package of Social Sciences version 25. Qualitative data were presented as numbers and percentages. Additionally, the Chi-Square test ($\chi 2$) or FET was used based on expected count per cell. Quantitative data were expressed as mean ± Standard Deviation (SD) if normally distributed or median if not.

The time to VAP distributions was compared for equality using the Log-rank test. Investigating the relationship between the time to VAP and one or more predictor factors involved the Cox proportional hazards model. The results were considered statistically significant if p value ≤ 0.050 for any of the used tests.

4.Results

Table 1 describes participants' socio-demographic characteristics. It showed that 51.1% of the intervention and control groups were aged above 60 years old with the mean age of 53.9 ± 18.5 and 57.9 ±16.2 years respectively. Additionally, 70.2% of the intervention group and 63.8% of the control group were males. Regarding the level of education, 25.5% of both groups had achieved a primary level of education. However, 36.2% of the intervention group had a Bachelor's degree level. Moreover, 63.8% of the intervention group and 72.3% of the control group were unemployed. The results also illustrated that 97.9% of the intervention group compared with 83% of the control group were non-smokers with a statistically significant

difference (p=0.030). No statistically significant differences were detected between the two groups regarding socio-demographic characteristics except for the current smoking status.

Table 2 presents participants' health relevant data. It illustrated that 95.7% of both studied groups diagnosed with traumatic brain injury (TBI). The majority of patients in the intervention and control groups were on a combined feeding method (87.2% & 91.5% respectively). Regarding the comorbidity, 46.8% of the intervention group and 51.1% of the control group had comorbidity. The most evident comorbidity in both groups was hypertension (38.3% & 44.7% respectively) followed by diabetes mellitus (25.5% & 31.9% respectively). No statistically significant differences were noted between the two groups regarding their health relevant data.

Table 3 illustrates the occurrence of VAP among both studied groups. It illustrated that the VAP incidence was 29.8% among all participants. The occurrence of VAP was higher in the control group (38.3%) than the intervention group (21.3%). The hazard ratio to develop the VAP in the control group was 4 times higher than the intervention group. As a result, they were more risky to acquire VAP than the intervention group (p=0.003).

Table 4 depicts the occurrence of VAP among the two studied groups after five days. It showed that there was a statistically significance difference in the occurrence of VAP between both groups on days 7 and 9 (P=0.014, 0.003 respectively). During these two days, the VAP was more evident in the control group than the intervention group. While, on day 11, no statistically significance differences were detected between the two studied groups.

Table 1 *Participants' Socio-demographic Characteristics*

Variables	Intervention Group	Control Group	Significance Test	
	n=47 No (%)	n =47 No (%)	χ^2 / t	*P* value
Age (years)				
• 18-30	9 (19.1%)	4 (8.5%)		
• 31-40	4 (8.5%)	6 (12.8%)		
• 41-50	5 (10.6%)	1 (2.1%)	FET	0.106
• 51-60	5 (10.6%)	12 (25.5%)		
• >60	24 (51.1%)	24 (51.1%)		
Mean ± SD	53.9 ±18.5	57.9 ±16.2	t=1.095	0.277
Gender				
• Male	33 (70.2%)	30 (63.8%)	334,0	0.510
• Female	14 (29.8%)	17 (36.2%)		
Education level				
• Illiterate	4 (8.5%)	8 (17%)		
• Primary	12 (25.5%)	12 (25.5%)		
• Preparatory	3 (6.4%)	9 (19.1%)	7,621	0.106
• Secondary	11 (23.4%)	10 (21.3%)		
• Bachelor	17 (36.2%)	8 (17%)		
Occupation				
• Employed	17 (36.2%)	13 (27.7%)	387,0	0.376
• Unemployed	30 (63.8%)	34 (72.3%)		
Smoking				
• Yes	1 (2.1%)	8 (17%)	FET	**0.030**
• No	46(97.9%)	39(83%)		

Data are expressed as numbers (No), frequency (%), χ2: Pearson Chi-square, FET: Fisher's Exact Test, t: Independent-Samples t-test, SD: Standard Deviation, statistically significant at $p \leq 0.050$

Table 2 *Participants' Health Relevant Data*

Variables	Intervention Group	Control Group	Significance Test	
	n =47 No (%)	n =47 No (%)	$\chi 2$	*P* value
Medical diagnosis				
• TBI	45 (95.7%)	45 (95.7%)		
• Poisoning	2 (4.3%)	0 (0%)	FET	0.245
• ENT disorder	0 (0%)	2 (4.3%)		
Feeding method				
• Enteral	4 (8.5%)	4 (8.5%)	FET	0.629
• Parenteral	2 (4.3%)	0 (0%)		
• Combined	41 (87.2%)	43 (91.5%)		
Comorbidity				
• Yes	22 (46.8%)	24 (51.1%)	0.170	0.680
• No	25 (53.2%)	23 (48.9%)		
Diabetes mellitus	12 (25.5%)	15 (31.9%)	0.468	0.494
Hypertension	18 (38.3%)	21 (44.7%)	0.394	0.530
Neurological disorders	9 (19.1%)	5 (10.6%)	1.343	0.247

Data are expressed as numbers (No) and frequency (%), $\chi 2$: Pearson Chi-square, FET: Fisher's Exact Test, TBI: Traumatic Brain Injury, ENT: Ear, Nose and Throat disorders

Table 3 *Incidence of Ventilator-Associated Pneumonia among Both Studied Groups*

Group	Number of VAP	Median (95% CI)	Log Rank (Mantel-Cox)		Cox Regression	
			χ^2	*P* value	HR (95% CI)	*P* value
Intervention	10 (21.3%)	-	13.048	**<0.001**	Reference 4 (1.6-9.8)	03
Control	18 (38.3%)	9 (7.7-10.3)				
Total	(28) 29.8%					

Data are expressed as median, CI: Confidence Interval, HR: Hazard Ratio, $\chi 2$: Pearson Chi-square, statistically significant at $p \leq 0.050$, highly statistically significant at $p < 0.001$

Table 4 *Occurrence of Ventilator-Associated Pneumonia after Five Days among the Studied Groups*

VAP (Days)	Intervention Group		Control Group		Significance Test	
	No	(%)	No	(%)	χ^2 / t	*P* value
Day 7	**n=42**		**n=37**			
• No VAP	37	88.1%	24	64.9%	6.034	**0.014**
• VAP	5	11.9%	13	35.1%		
Mean ± SD	3.07 ±1.33		4.35 ±1.35		t= 4.22	**<0.001**
Day 9	**n=26**		**n=10**			
• No VAP	25	96.2%	5	50%	FET	**0.003**
• VAP	1	3.8%	5	50%		
Mean ± SD	2.88 ± 0.909		4.80 ±1.31		t= 4.98	**<0.001**
Day 11	**n=22**		**n=3**			
• No VAP	21	95.5%	3	100%	FET	1
• VAP	1	4.5%	0	0%		
Mean ± SD	3.45 ± 0.80		3.67 ±0.577		t= 0.44	0.664
Day 13	**n=16**					
• No VAP	13	81.3%	-			

• VAP	3	18.8%	
Mean ± SD	3.75 ± 1.34		
Day 15	**n =7**		
• No VAP	7	100%	-
• VAP	0	0%	
Mean ± SD	3.14 ±0.90		
Day 17	**n=3**		
• No VAP	3	100%	-
• VAP	0	0%	
Mean ± SD	3.33 ± 1.15		

Data are expressed as numbers (No) and frequency (%), $\chi 2$: Pearson Chi-square, t: Independent-Samples t-test, VAP: Ventilator Associated Pneumonia, SD: Standard Deviation, statistically significant at $p \leq 0.050$, highly statistically significant at $p < 0.001$.

5.Discussion

The current study aims to investigate the effect of ventilator circuit change every five days on the occurrence of ventilator-associated pneumonia among critically ill patients. It involved a sample of 94 participant patients, they were randomly assigned into two groups: the intervention group and the control group. The intervention group received 5-day VCC and the control group had the routine change.

The results of the current study found that slightly more than half of patient in the two study groups were over 60 years old. These findings are consistent with the results of a recent study which investigated the effect of open and closed suction techniques on the incidence of VAP and revealed that the mean age of their participants was 57.91 ± 19.9 **(Ardehali, Fatemi, Rezaei, Forouzanfar, & Zolghadr, 2020)**. However, a study conducted by **Arumugam et al. (2018)** evaluated the risk factors for VAP in trauma patients and reported that the average age of their participants was 30.7 ± 14.8. This discrepancy may be due to differences in their study setting and the inclusion criteria, since their study was carried out in the trauma room.

The current findings showed that the male gender was dominant in the studied groups. This may be because males have a more prominent participation in everyday life and devote greater time in potentially dangerous situations than women **(Duran & Uludağ, 2020)**. Furthermore, they are regarded as the primary workers in most nations, which expose them to greater risk that leads to ICU admission. In line with the current findings, **Takahama et al. (2021)** found that the majority of their participants were men. On the other hand, **Kaya et al. (2017)** reported that nearly two-thirds of their research groups were females. This may be owing to variations in the study setting since their research took place in a neurosurgical ICU, where neurological diseases were more common among females **(Attarian, Brandes, Dafer, Gerard, & Giesser, 2015)**.

Concerning the educational level, the current study revealed that one-quarter of the intervention and the control group had completed a primary level of education. However, the biggest proportion of the intervention group had a Bachelor's degree level. This is consistent with **Aysha et al. (2016)** study which showed that nearly one-quarter of their participants had a primary level of education. However, **Abd El-hamid, Shams, El-moaty, Ali, and Awad (2017)** examined the effect of employing different modalities of chest physiotherapy on the prevention of VAP and revealed that the primary level of education accounts for just 2.5 % of both groups.

The results of the current study revealed that most patients in the two groups were unemployed. This may be because slightly more than half of our research groups were elderly (>60 years) and retired according to the Egyptian government regulations. These findings are not in line with **Aysha et al. (2016)** investigation, which reported that nearly two-thirds of their participants were

working. This contradiction may be due the younger age of their studied sample.

The current findings revealed that the majority of the studied groups were non-smokers. Smoking was thought to be more prevalent among teenage patients, but in our sample, the old outnumbered the young. This is consistent with an Egyptian study that examined the prevalence of VAP in CIPs and showed that around two-thirds of the participant patients did not smoke **(Ali, Abd El mawla, & Ahmed, 2020)**. On the other hand, **Aysha et al. (2016)** found that more than half of both the intervention and control groups were smokers. This inconsistency may be due to the younger age of the enrolled sample in their studied groups.

Traumatic brain injury was the most common medical diagnosis among the studied groups. Globally, it is the primary cause of one-third to one-half of all trauma-related injuries, and is the leading cause of mortality and disability **(Iaccarino, Carretta, Nicolosi, & Morselli, 2018)**. Worldwide, it is estimated that 69 million people experience a TBI each year **(Dewan et al., 2019)**. The incidence of TBI increases in the elderly population and in developing countries **(Hawryluk & Bullock, 2016)**. In Egypt, road traffic accidents and assault were the two most frequent causes of TBI, with the skull fractures and intracranial hemorrhage are the common recorded complications **(El-Farouny, 2021)**.

Concerning feeding methods, the majority of both studied groups received a combination of enteral and parenteral feeding. There is a debate about which method of nutrition is better for CIPs. Early enteral feeding within 48 hours of admission is frequently advised in ICUs **(Padilla et al., 2019)**. Parenteral nutrition has been used to fulfil the nutritional needs for patients who are unable to tolerate sufficient enteral nutrition **(Zhao, Ziegler, & Davis, 2020)**. It should be applied within 3-7 days if recommended **(Gostyńska, Stawny, Dettlaff, & Jelińska, 2019)**. Additionally, combining enteral and parenteral nutrition as soon as a patient admitted to the ICU is one way to maximize protein intake and achieve the nutrition goals as soon as feasible if they are at nutritional risk **(Hill et al., 2020)**.

The current findings indicated that the most frequently encountered comorbidities were hypertension and diabetes in both groups. The **International Diabetes Federation (2021)** estimates a sustained global growth in diabetes prevalence; it affects 537 million individuals aged 20 to 79 years, with the number estimated to increase to 643 million by 2030 and 784 million by 2045. In Egypt, the prevalence of diabetes was one fifth in 2021, with an anticipated rise to nearly one quarter by 2045. There are 1.28 billion people with hypertension worldwide between the ages of 30 and 79, with lower-middle-income countries accounting for two-thirds of them **(WHO, 2021)**. Approximately 29.2 % of Egyptian adults have hypertension **(WHO, 2017)**.

Our results are consistent with certain studies which investigated the risk factors for VAP and illustrated that hypertension and diabetes were the most prevalent comorbidities among their participants **(Deshmukh, Kadam, Thirumugam, & Rajesh, 2017; Kózka, Sega, Wojnar-Gruszka, Tarnawska, & Gniadek, 2020)**. However, **Triamvisit et al. (2021)** investigated the effect of modified care bundle for prevention of VAP in CIPs in Thailand and found that nearly two-thirds of the participants had no comorbidity in their study. This discrepancy may be attributed to the healthy food and medical care received in this country **(Chris, 2018)**.

The VAP incidence was 29.8% among all participants in the current study. Additionally, the incidence of VAP was greater among the control group than in the intervention group with a highly statistically significant difference between them. This indicates that changing the ventilator circuits every five days is an efficient method of reducing the occurrence of VAP among CIPs. **Chu et al. (2015)** evaluated the effects of 1-week versus 2-day VCC on the occurrence of VAP and found that switching from 2-day to 1-week VCC was risk-free, economical, and did not increase the rate of VAP.

Moreover, according to **Hsieh et al. (2010)** study which compared 3-day versus 7-day VCC found that incidence of VAP per 1000 ventilation days was 10.75 for 3-day circuit change and 8.41 for 7-day change respectively. So, weekly change of the ventilator circuits is safe and did not lead to an increase in VAP occurrences. Additionally, **Samransamruajkit et al. (2010)** compared 3-day versus 7-day VCC on the rate of VAP and showed that compared to the 7-day circuit change, the 3-day had a VAP rate of 13.9/1000 ventilator days as opposed to 11.5/1000 ventilator days. So, the 7-day change did not lead to an increase in VAP rates.

In a systematic review examined the influence of VCC on the incidence of VAP, **Liu et al. (2017)** concluded that patients who had circuit change every 7 days had a lower chance of acquiring pneumonia than those who got it once a day. Therefore, replacing the ventilator circuits every 7 days in patients receiving MV is more rationale and acceptable. Increased ventilator circuits manipulation allows contaminated secretions to reach the bronchial tree via the lumen of endotracheal tube, adding to an increase the risk of VAP **(Hellyer, Ewan, Wilson, & Simpson, 2016)**. It was noted that the above mentioned studies occurred in pediatrics, neonates and children. The appropriate frequency of VCC concerning the VAP occurrence has been rarely investigated in adults.

There was a statistically significant difference in the occurrence of VAP between our studied groups on the 7th and 9th days. In these days, the VAP occurred more frequently in the control group than in the intervention group. This might be due to a lack of VCC in the control group. These findings are consistent with **AbdEl–Aziz, Soliman, and Ibrahim (2020)** investigation, which found a highly statistically significant difference in the occurrence of VAP on the seventh day between their studied groups. Similarly, **Khalil, Elsayd, Ibrahim, and Elshafey (2019)** reported high statistically significant differences between their studied groups regarding CPIS score after day 7. As a result, the current data are consistent with the previously described VAP prevalence as the modified
CPIS was our VAP occurrence predictor.

6.Conclusion and Recommendations

The current study findings support the evidence-based practice related to the care of mechanically ventilated patients. Changing the ventilator circuits every 5 days is a safe practice and can significantly reduce the occurrence of VAP among CIPs. Therefore, this practice should be adopted by critical care nurses as a part of mechanically ventilated patients' care and included in hospital infection-control policies. Furthermore, large scale studies are needed to enrich the evidence related to mechanically ventilated patients' care.

7. Limitations

The limited sample size and the collection of data from one hospital restrict the generalizability of the study findings. Early VAP was not studied, which is suggested to be further evaluated in future investigations.

8. Acknowledgment

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9. Declaration of competing interests

There are no potential conflicts of interest.

10. References

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