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Original Article

Relationship Between Demographic Characteristics, Clinical Parameters, and Extubation Time in Post-Cardiac Surgery Patients

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ABSTRACT

Background: Understanding factors influencing extubation in cardiac surgery patients is essential. This study aimed to determine the relationship between demographic characteristics, medical and clinical variables, and the extubation time in patients undergoing cardiac surgery in a cardiovascular center.

Methods: This causal-comparative study was conducted on 210 adult patients who underwent cardiac surgery in 2018 in Tehran. The study samples were selected via the convenience sampling method. The data collection tool was a researcher-made observation checklist that featured 4 sections on the patients' demographic characteristics, clinical variables during surgery, clinical conditions in the ICU, and high-risk factors related to the disease. The subjects were categorized into 2 study groups of more than 6 hours of mechanical ventilation and equal to or less than 6 hours of mechanical ventilation based on their mechanical ventilation time. Via the multivariate analysis test, the factors affecting endotracheal tube extubation were determined. IBM SPSS Statistics software, version 21, was used for statistical analysis.

Results: The study population consisted of 210 post-cardiac surgery patients, 142 men and 68 women, at a median age of 55 years. The findings indicated that age, sedation, and the duration of pulmonary circulation had a significant influence on the extubation time in post-cardiac surgery patients.

Conclusions: In our sample of post-cardiac surgery patients, age, sedation, and the duration of pulmonary circulation impacted the process of extubation. The implementation of a precise discontinuation program from mechanical ventilation by considering these factors is recommended to prevent long-term mechanical ventilation and shorten the ICU length of stay. ***(Iranian Heart Journal 2022; 23(1): 140-148)***

KEYWORDS: Extubation of the endotracheal tube, Cardiac surgery, Intensive care, Mechanical ventilation

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The first goal after mechanical ventilation and endotracheal intubation is to begin the process of discontinuing mechanical ventilation and removing the endotracheal tube (Crawford et al, 2016; Flynn et al, 2019; Williamson et al, 2017). Typically, there are 2 common methods to discontinue mechanical ventilation and remove endotracheal tubes. In the conventional method, the process of extubation is performed within 12 to 24 hours after the surgery, whereas in the fast or rapid method, the process of discontinuation from mechanical ventilation is done within 1 to 6 hours. Today, rapid discontinuation is defined as performing extubation within the first 6 postoperative hours. The purpose of the rapid extubation method comprises a faster recovery, a faster discharge from the intensive care unit (ICU), and preventing the potential complications of long-term mechanical ventilation and intubation (Marda et al, 2016).

Historically, from the 1960s, it was recommended that patients who undergo cardiac surgery be mechanically ventilated for 24 hours due to frequent post-cardiac surgery respiratory complications. Nonetheless, attention was paid to the rapid method of discontinuation from mechanical ventilation in the post-cardiac surgery care program in 1990 to reduce the complications of respiratory function and gas exchange during the recovery period. In 1994, the protocol of the rapid discontinuation method from mechanical ventilation in the ICU was proposed (Williams and Murphy, 2016), and it has been employed since 1995 as the routine protocol.

Rapid discontinuation from mechanical ventilation and endotracheal tube removal in post-cardiac surgery patients are clinically important because of their benefits and fewer complications compared with long-term mechanical ventilation (Marda et al, 2016, Mukerji et al, 2020). Additionally, the utilization of short-acting anesthetics such as propofol and minimizing drug use can facilitate endotracheal tube removal and mechanical ventilation discontinuation (Amula et al, 2019). Although the results of various studies indicate that the process of fast discontinuation from mechanical ventilation and endotracheal tube removal in most patients undergoing cardiac surgery is safe, there is a controversy surrounding the application of the process in some settings. Many factors also affect the process, facilitating or limiting its implementation. Identifying the factors influencing endotracheal tube removal plays an important role in proper rapid discontinuation from mechanical ventilation and extubation, conferring a better estimation of the patient's survival time in the ICU. Knowing the factors that affect the removal of the endotracheal tube allows one to plan and implement a more effective care program after extubation by anticipating possible problems in patients (Martinos et al, 2017, Tierney et al, 2019). The results of various studies suggest that some demographic variables such as age and obesity or preoperative medical factors such as renal failure, pulmonary disease, heart disease, and the left ventricular ejection fraction may have an impact on the time of endotracheal tube removal (Gumus et al, 2015).

Rapid discontinuation from mechanical ventilation reduces the cost of hospitalization and the length of stay in the ICU and the hospital. In addition, fast discontinuation from mechanical ventilation enables patients to communicate verbally and, thus, reduces their anxiety and their need for sedative agents (Bainbridge and Cheng, 2015, Ramoncito et al, 2017). On the other hand, the consequences of late endotracheal tube extubation include lung damage caused by air leaks during mechanical ventilation, resulting in an

excessive pressure increase in alveoli and causing alveoli collapse; hospital-acquired pneumonia, caused by air conditioning; the risk of airway contamination; decreased cardiac output due to impaired venous return by positive pressure ventilation; decreased renal perfusion; gastrointestinal dysfunction; and patients' inconsistency with ventilation and their mental distress.

The number of patients in need of cardiac surgery costs healthcare systems a great deal; accordingly, the process of fast discontinuation from mechanical ventilation is considered a helpful approach to decrease healthcare costs in this group of patients. However, identifying the factors that impact the process is crucial to commence the process safely. Although several studies have examined the relationship between 1 or more of these demographic factors and clinical variables with endotracheal tube removal, few studies have investigated the relationship between a large number of demographic factors and clinical variables and the time of extubation. The purpose of this study was to investigate the relationship between demographic characteristics, clinical parameters, and the extubation time in post-cardiac surgery patients in Rajaie Cardiovascular Medical and Research Center.

METHODS

This causal-comparative study was performed on patients admitted to the ICUs in Rajaie Cardiovascular Medical and Research Center after cardiac surgery due to the need for mechanical ventilation. The research sample in this study was selected using the available sampling method from the research community and based on inclusion and exclusion criteria. The data collection tool was a demographic data collection sheet and a researcher-made observational checklist of clinical variables taken from the patients' documents. Data were collected and recorded by a researcher engaged with the patient. Inclusion criteria consisted of potential candidates for coronary artery bypass grafting or replacement (or repair) of 1 or more heart valves between 18 and 70 years of age, complete alertness, and a lack of pulmonary-renal and hepatic dysfunction. Exclusion criteria included cognitive impairment and renal failure after surgery, emergency surgery, and unstable cardiovascular conditions (ie, tamponade, myocardial infarction, ventricular tachycardia, ventricular fibrillation, and cardiac arrest in the ICU). In addition, patients with extensive vascular instability of the coronary arteries necessitating the use of aortic pump balloons or external membrane oxygenation devices and patients in need of surgery were excluded from the study.

After surgery, from the time of patients' admission into the ICU and following the commencement of mechanical ventilation with a well-defined protocol (agreement) by ICU nurses and under the supervision of an anesthesiologist (assistants of the anesthesiology course), discontinuation began, and its beginning time (ICU admission) and the time of endotracheal tube extubation were recorded. The arterial blood gas test was taken every 2 hours until the endotracheal tube was removed. Taking into account the duration of extubation and using the statistical test of logistic regression, we divided the study population into 2 groups of respiration with mechanical ventilation for more than 6 hours and respiration with mechanical ventilation for 6 hours or less. All the data were recorded and registered by the researcher. Additionally, information on 4 main areas of the patients' demographic characteristics (4 variables: age, sex, height and weight, and marital status), risk factors associated with heart disease (6 variables: the disease diagnosis, the left ventricular ejection fraction, a history of diabetes, a

history of high blood pressure, a history of smoking and drug use, and a history of respiratory disease), the clinical condition of the patient in the ICU (13 variables: the patients' alertness, the volume of fluid leakage from chest tubes, abnormal blood gas laboratory findings from arterial blood gases [arterial oxygen partial pressure, P_aO_2 <60 mm Hg, arterial carbon dioxide partial pressure [P_aCO_2 >50], and base excess [BE] less than −10], the hemoglobin level, the creatinine level, the urine output volume [if reduced to <0.5 mL per kg of the patient's weight per hour], the left ventricular ejection fraction, the need for sedatives, and blood products) and clinical criteria during surgery (6 variables: the duration of the aortic clamp, the duration of cardiac-pulmonary pumping, the duration of surgery, the use of intra-aortic balloon pumps, the type of surgery, and cardiovascular performance-enhancing drugs) were collected and recorded by the researcher engaged with patients.

RESULTS

Our examination of the clinical findings and information during surgery via a single-variable analysis (Table 1) showed that age, the duration of pulmonary circulation, the duration of clamping the aortic artery, the duration of surgery, the use of sedatives, the use of blood products, lung liquid secretion, and the use of inotropic agents in the ICU were significantly different between the 2 study groups (P>0.05). Our multivariate analysis with the aid of a logistic regression model revealed that age, the use of sedatives, and the duration of pulmonary circulation had a significant and justified correlation with mechanical ventilation for more than 6 hours (P>0.01). The significance for sedatives was higher than that for the other factors (Table 2).

Table 1. Comparison of the individual characteristics of the participants in the 2 study groups

Variables	Extubation < 6 h (n=17)	Extubation > 6 h (n=193)	*P* value
Age (range)	34 (61-21)	55 (63-46)	0.023
Sex (female/male)			
Male (%)	10 (58/8)	132 (68/4)	0.419
Female (%)	7 (41/2)	61 (31/6)	
Body mass index kg/m^{2-}(range)	25 (22. 1-27.5)	26 (23. 62-29)	0.117
History of smoking (%)	2 (11/8)	50 (25/9)	0.251
History of addiction (%)	1 (5/9)	32 (16/6)	0.483
Disease History			
Diabetes (%)	1 (5/9)	52 (26/9)	0.078
High blood pressure (%)	5 (29/4)	79 (40/9)	0.353
Pulmonary disease (%)	2 (11/8)	46 (23/8)	0.371
Clinical Findings			
Number of breaths (range)	12 (12-2)	12 (12-2)	0.778
Number of heartbeats	88 (76.5-100)	87 (100-78)	0.907
Left ventricular ejection fraction (%)	50 (37/50-50)	45 (50-35)	0.934
Arterial_sys mm Hg-	120 (130-110)	110 (130-98)	0.095
Arterial_dia mm Hg-	70 (60-77.5)	67 (55-72)	0.100
Paraclinical Findings			
Creatinine mg/dL-(range)	0.7 (0.6-0.85)	0.8 (0.1-7)	0.097
Hemoglobin g/dL-(range)	10.9 (10.1-11.7)	10.5 (9. 35-11.3)	0.107
Surgical Findings			
Duration of pulmonary circulation (range)	66 (47.5-90.5)	85 (67.5-106.5)	0.034
Duration of aortic artery clamping (range)	30 (22.5-50)	45 (65-35)	0.004
Duration of surgery (range)	180 (165-210)	220 (180-255)	0.024

Central venous pressure mm Hg-(range)	12 (2-12)	12 (2-12)	0.690
SPO_2 (%)	88 (76.5-100)	87 (78-100)	0.247
Inotropic agents during surgery (%)	2 (11/8)	59 (30/6)	0.161
Sedatives (%)	6 (35/3)	136 (70/5)	0.005
Blood products (%)	2 (11/8)	72 (37/3)	0.036
Findings of Arterial Gases			
PaO_2 <60 mm Hg-(%)	1 (5/9)	24 (12/4)	0.71
PCO_2> 50 mm Hg-(%)	1 (5/9)	25 (13)	0.701
base excess < −10 (%)	0 (0)	31 (16/1)	0.083
Clinical Findings			
Lung liquid secretion	100 (250-50)	250 (400-125)	0.007
Inotropic agents in the ICU	2 (11/8)	55 (28%/5)	0.0165

Table 2. Multivariate analysis to investigate the correlated relationship of the factors affecting the time of mechanical ventilation for more than 6 hours

Variables	95% CI for OR		Odds Ratio	*P* value	SE	Coefficient
Age	1.084	1.008	0.045	0.017	0.019	0.044
Duration of pulmonary circulation	1.031	0.999	1.015	0.068	0.008	0.015
Lung liquid secretion	1.006	0.999	1.003	0.117	0.002	0.003
Sedatives	10.952	1.184	3.601	0.024	0.568	1.281

DISCUSSION

The aim of this study was to determine the relationship between the demographic and medical factors of patients and clinical variables and the time of the extubation of the endotracheal tube after cardiac surgery in the ICU of Rajaie Cardiovascular Medical and Research Center. Based on the results of this study, age, the duration of pulmonary circulation, lung liquid secretion, and the use of sedatives had a significant relationship with mechanical ventilation for more than 6 hours. Regarding the variable of age, studies that are not consistent with this study include those by Bansal et al, Savari et al, Banskar et al, Baskar Karthekeyan et al, and Savari et al. On the other hand, according to a previous study, age is related to the extubation of the endotracheal tube (Faghani et al, 2017).

We found a significant difference between our 2 groups of respiration with mechanical ventilation for more than 6 hours and respiration with mechanical ventilation for 6 hours or less in terms of the following variables: the duration of aortic clamping, the duration of surgery, and the duration of pulmonary circulation (P>0.05). Vis-à-vis the relationship between pulmonary circulation and the endotracheal tube extubation time, our finding is not supported by the results reported by Barkhordari with a *P* value of 0.66 (Barkhordari et al, 2016), whereas in Rezaianzadeh's study with a *P* value of 0.01, this relationship was significant (Rezaianzadeh et al, 2015). Further, the time of aortic clamping, which is significant in the present study, is not consistent with that in the research by Barkhordari and Rezaianzadeh (Barkhordari et al, 2016; Rezaianzadeh et al, 2015) but is consistent with the study conducted by Sato (Sato et al, 2009). Prolonged aortic clamping is an effective factor in delaying the extubation time in ventricular defect surgery (Baskar Karthekeyan et al).

The results of the present study showed that patients who underwent painless infusion of and sedation with propofol were significantly different during the time of discontinuation from the mechanical ventilation. This finding does not correspond with that reported by Jafroudi (Jafroudi et al, 2014). In the rapid removal of the endotracheal tube compared with routine

removal, patients undergoing cardiac surgery show fewer depressive symptoms in the first 3 postoperative days. Monitoring anesthetic drugs during cardiac surgery may play an important role in patients' health by reducing the prevalence of postoperative depression. Propofol modulates mood, which may be responsible for reducing the prevalence of postoperative depression (Myles et al, 1997). Still, Angwin et al concluded that dexmedetomidine shortened the time of extubation and curtailed admission to the ICU and the hospital compared with propofol and warned that sedative protocols still needed to be developed (Nguyen and Nacpil, 2018).

For the long-term tranquilization of patients with mechanical ventilation, regardless of rapid extubation, Zhou et al concluded that the use of midazolam and propofol together, which constitutes a safe and effective sedative protocol, had a higher clinical efficacy and was more cost-beneficent than the use of each of them independently (Zhou et al, 2014). Safavi's research findings showed that preoperative training in cardiac surgery concerning mechanical ventilation and its discontinuation not only reduced the consumption of sedatives during mechanical ventilation and discontinuation but also shortened the duration of intubation (Safavi et al, 2005). The results of a study by Mirinezhad et al indicated that the use of propofol in patients with coronary artery surgery reduced postoperative mechanical ventilation and the length of stay in the ICU compared with midazolam, without increasing hemodynamic and ischemic complications (Mirinezhad et al, 2005).

In a prospective clinical study of 180 patients who underwent heart surgery from January through June 2004, a comparison of 3 anesthesia strategies with respect to the extubation time after coronary artery bypass graft surgery was considered after the induction of anesthesia. Generally, patients were divided into 3 groups, and all of them received a continuous intravenous injection of propofol before and after surgery. Group I received a simultaneous injection of fentanyl (60 patients), Group II received a concomitant diclofenac suppository (60 patients), and Group III received a simultaneous injection of remifentanil (60 patients). Postoperative ventilation until endotracheal tube extubation, inotropic need, the analgesic infusion time, arterial blood gas analysis after intubation, pain assessment, and the duration of stay in the cardiac surgery unit were assessed in each patient. The results indicated that the diclofenac group showed the shortest time to remove the endotracheal tube, the lowest inotropic dose, and the lowest anti-pain dose compared with the patients in the other 2 groups. Based on the findings of that study, intravenous propofol combined with nonsteroidal anti-inflammatory drugs (NSAIDs) conferred the best improvement in patients undergoing cardiac surgery compared with the other 2 methods (Maddali et al, 2006). This study showed that the volume of tubular secretions from the chest was affected by the duration of mechanical ventilation of cardiac surgical patients. The results are consistent with those in a retrospective study in 2015 by Brims et al, who examined the effects of extracting the pleural fluid on the pulmonary function of patients in need of mechanical ventilation. Both prove that pleural fluid evacuation is concomitant with rapid and sustained improvements in oxygen delivery, and the accumulation of these fluids in the lungs prolongs mechanical ventilation (Brims et al, 2015).

Limitations of the Study

One of the inclusion criteria, namely the non-emergency nature of cardiac surgery, is one of the limitations of the current study.

Therefore, sampling after surgery was not possible on formal and informal holidays.

CONCLUSIONS

The results of this study showed a significant relationship between demographic and medical factors in patients undergoing cardiac surgery and their clinical outcomes during surgery. Paying sufficient heed to these factors allows the proper process of endotracheal tube extubation, the implementation of precise care programs to prevent long-term mechanical ventilation, and the reduction of the length of stay in the ICU. Rapid endotracheal tube extubation is performed for almost all patients after thoracic and cardiac surgical operations due to the many benefits of this method. With proper techniques during extubation, cardiac surgical patients can be discharged without major complications within 6 hours. The variables affecting the duration of mechanical ventilation in this study were age, the duration of pulmonary circulation, the duration of aortic clamping, the duration of surgery, the use of sedatives, the use of blood products, lung liquid secretion, and the use of inotropic agents in the ICU. The significance of the relationship in the case of the use of sedatives was higher than that for the other factors. We recommend that nurses pay more attention to the assessment of the variables that affect the duration of mechanical ventilation when examining patients' readiness for the discontinuation of mechanical ventilation devices and endotracheal tube removal.

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Conflict of Interest

There is no conflict of interest in the compilation of this article.

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