

Mechanical Ventilation Time and Mortality After Coronary Artery Bypass Grafting: A Cohort Study

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Abstract

Introduction: Cardiac surgery is a procedure that requires great assistance and care. In this way, patients are sent to the intensive care unit (ICU), where they are connected to mechanical ventilation (MV). Prolonged treatment of these patients worsens clinical outcomes and leads to mortality.

Objective: To evaluate the impact of MV time on patients undergoing cardiac surgery.

Methods: This is a retrospective cohort study. After surgery, patients were admitted to the ICU and connected to MV. The entire ventilation adjustment and weaning process was conducted according to the unit's routine. They were divided into two groups, patients who continued on MV for more than eight hours and those who remained for less than eight hours. From this, univariate and multivariate analyses were carried out between predictor variables — MV time, age, sex, and cardiopulmonary bypass (CPB) time — and mortality. We considered $p < 0.05$ as significant.

Results: A total of 110 patients were evaluated, 25 stayed on MV for more than eight hours. In the univariate analysis, MV time was associated with mortality (HR 0.7 [0.3–0.9], $p = 0.01$), remaining in the multivariate analysis (HR 0.4 [0.2–0.6], $p = 0.01$). The other variables were not associated with death outcome.

Conclusion: MV time of more than eight hours is a predictor of mortality after cardiac surgery, given the contribution of some risk factors.

Keywords: Artificial Respiration; Mortality; Thoracic Surgery.

Introduction

Cardiac surgery is a complex and invasive procedure that leads to critical postoperative conditions. This type of procedure is employed to treat cardiovascular diseases.¹ As it is considered a major procedure, it requires extensive assistance and care. That is why patients who undergo this type of surgery are sent to the intensive care unit (ICU) and kept there under intensive care until their hemodynamics, level of consciousness, and respiratory and cardiovascular functions are restored in the first few hours after surgery. However, some patients remain longer on mechanical ventilation (MV) and this may be associated with mortality.²

Some complications can prolong the time a patient spends on MV. Pulmonary complications are very common in the post-surgical period and are associated with factors

such as age, male gender, previous illnesses — systemic arterial hypertension, diabetes mellitus, chronic obstructive pulmonary disease, chronic renal insufficiency, and length of time the patient is on cardiopulmonary bypass (CPB).³ As a result, the prolonged MV stay can increase mortality risk.⁴

It is pertinent to consider the risk aspects before admitting a patient, as care during support is also a reflection of the time spent in hospital. In addition, it is important to know the previous reasons why MV may be prolonged after surgery. Patients who remain on MV for a long time suffer physical deconditioning due to sedation, which causes muscle weakness in the diaphragm, thus increasing mortality. Another factor contributing to the high mortality rate is that these patients are more susceptible to ventilator-induced lung damage. Failure to wean is also a factor that contributes to the same outcome.⁵

The length of MV in patients undergoing cardiac surgery can increase the severity of the case and even lead to mortality since many of these patients have complications that are already postoperative. In those patients who stay longer, mortality is the result of cardiogenic shock, cardiac arrest, renal failure, multiple organ failure, and sepsis.⁶

It is known that a large number of patients are hospitalized due to cardiovascular diseases and that in many cases the intervention needs to be surgical. There are still few studies that make this type of correlation, so the present work can provide

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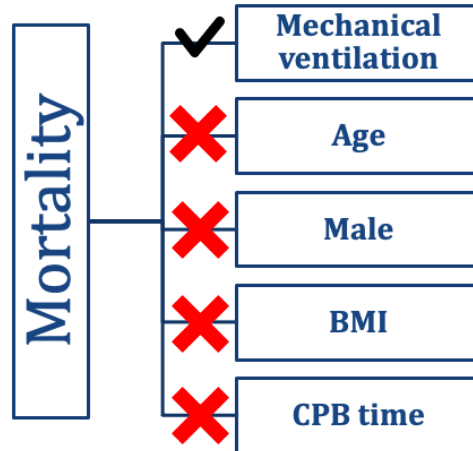
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Central Illustration: Mechanical Ventilation Time and Mortality After Coronary Artery Bypass Grafting: A Cohort Study



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BMI: body mass index; CPB: cardiopulmonary bypass.

relevant data for the creation of protocols within hospitals. Therefore, the aim of this study is to correlate MV time with mortality in patients who have undergone cardiac surgery.

Methods

Study design

This is a retrospective cohort study of patients who underwent cardiac surgery at the Instituto Nobre de Cardiologia, from January 2018 to February 2020.

Inclusion and exclusion criteria

The following inclusion criteria were applied: individuals of both sexes, aged over 18, and undergoing cardiac surgery via median sternotomy and CPB. Patients who were admitted to the ICU without MV, with insufficient clinical and surgical data, without MV data, urgent/emergency surgery, previous pulmonary and/or kidney disease, and patients who failed weaning were excluded.

Study protocol

Initially, all clinical data (laboratory tests, medications, clinical reports) and diseases such as diabetes mellitus, systemic arterial hypertension, dyslipidemia, acute myocardial infarction, peripheral vascular disease, immunosuppression, renal failure, and the sedentary lifestyle of patients were observed during the preoperative period. Surgical characteristics were also assessed. All these comorbidities were known through each patient's medical records, except for the sedentary lifestyle. With this respect, the International Physical Activity Questionnaire (IPAQ) was applied in the long format, which

assesses 27 questions relating to physical activities carried out in a normal week, with light, moderate, and vigorous intensity, lasting ten minutes continuously, and divided into four categories of physical activity such as work, transportation, domestic activities, and leisure. Those who did not perform any physical activity for at least ten minutes continuously during the week were considered sedentary.

The day after the assessment, patients were sent to the operating room and then to the ICU, where the MV process and the care provided by the multi-professional team were performed according to the service's routine. The patients were connected to the mechanical ventilator in volume-controlled ventilation (VCV) mode with 6 mL/kg, respiratory rate of 14 ipm, flow of 40 L/mL, positive end-expiratory pressure (PEEP) of 5 cmH₂O, sensitivity of -2, and fraction of inspired oxygen (FiO₂) of 60%.

After a patient has woken up, the weaning process begins. In order to carry it out, it is necessary to know if the patient is eligible for the spontaneous breathing test (SBT), through some evaluation criteria, such as: having ventilatory drive, hemodynamic stability, no previous procedure, having the cause of respiratory failure resolved or controlled, having a partial pressure of oxygen (PaO₂) $\geq$ 60 mmHg, with FiO₂ $<$ 0.4 and with PEEP 5–8 cmH₂O, zero or negative water balance in the last 24 hours, and normal acid-base and electrolyte balance. Therefore, the SBT was carried out in pressure support ventilation (PSV), where the patients continued to be connected to the ventilator but with a lower support pressure (7cm H₂O). The main advantage of this test is that all the patients' information is kept, as they remain connected to the ventilator.

The SBT lasted between 30 and 120 minutes. The physiotherapist assessed whether the patients responded well

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to the test; if they showed signs of intolerance in the first 30 minutes, the test was stopped. From this, two groups were formed: patients who remained on MV for more than eight hours and those who stayed for less than eight hours. Predictor variables (MV time, age, gender, and CPB time) and mortality were compared between these groups.

Statistical analysis

Data normality was confirmed using the Shapiro-Wilk test and expressed as mean and standard deviation. Categorical variables were presented as absolute values and percentages. The chi-square test was used for the evaluation of categorical variables. The independent Student's t-test was applied to the continuous variables. We then adjusted the association between MV duration and the primary outcome through a multivariable Cox proportional hazards model, adjusting for MV, age, sex, body mass index (BMI), and extracorporeal circulation time. All statistical significance tests were two-tailed with an alpha level of 0.05. The analyses were performed using Statistical Package for Social Sciences (SPSS) version 20.0 and R version 2.14.113. Data were considered statistically significant if the p-value was $p < 0.05$.

Results

A total of 110 patients were assessed in this study. The sample was gathered for convenience and divided into two groups: those who remained on MV for less than eight hours and another with those who stayed on MV for more than eight hours.

Table 1 shows that the majority of patients were male, with 66 people (60%), the average age was 57 standard deviation ($\pm$) 8 years and the main comorbidity was a sedentary lifestyle, which was found in 79 people (72%). The other data were not significant between the groups, except for CPB time, which was higher in the group that stayed for more than eight hours ($p = 0.03$).

Table 2 shows some of the variables that were analyzed: MV, age, male gender, BMI, and CPB time. However, among these variables, MV time was associated with increased mortality (Central Illustration).

Discussion

The study sought to investigate the relationship between MV time and mortality in patients who had undergone cardiac surgery. The results showed that the main variables related to mortality were male gender, MV, age, BMI, and CPB time.

Table 1 – Clinical and surgical variables of the patients studied.

Variable	Total (n = 110)	<8 hours (n = 85)	>8 hours (n = 25)	p
Gender				
Male	66 (60%)	49 (58%)	17 (68%)	0.43
Female	44 (40%)	36 (42%)	8 (32%)	
Age (years)	57 $\pm$ 8	55 $\pm$ 8	60 $\pm$ 9	0.51
BMI (kg/m²)	24 $\pm$ 4	24 $\pm$ 3	25 $\pm$ 4	0.75
Comorbidities				
DM	44 (40%)	35 (41%)	9 (36%)	0.54
SAH	68 (62%)	53 (62%)	15 (60%)	0.79
DLP	31 (31%)	21 (25%)	10 (40%)	0.43
Sedentary lifestyle	79 (72%)	61 (72%)	18 (72%)	0.91
AMI	15 (14%)	10 (12%)	5 (20%)	0.45
NYHA				
I	14 (13%)	11 (13%)	3 (12%)	0.78
II	39 (35%)	35 (41%)	4 (16%)	0.02
III	44 (40%)	29 (34%)	15 (60%)	0.03
IV	13 (12%)	10 (12%)	3 (12%)	0.87
CPB time (min)	100 $\pm$ 15	90 $\pm$ 12	112 $\pm$ 16	0.03
EF (%)	38 $\pm$ 4	35 $\pm$ 3	39 $\pm$ 4	0.67
Number of grafts	2 $\pm$ 1	2 $\pm$ 1	2 $\pm$ 1	0.89

p: p-value; $\pm$: standard deviation; BMI: body mass index; DM: diabetes mellitus; SAH: systemic arterial hypertension; DLP: dyslipidemia; AMI: acute myocardial infarction; NYHA: New York Heart Association; CPB: cardiopulmonary bypass; EF: ejection fraction.

Table 2 – Univariate and multivariate associations between predictive variables and mortality.

Predictors	Univariate HR	p	Multivariate HR	p
MV	0.7 (0.3–0.9)	0.01	0.4 (0.2–0.6)	0.01
Age	0.8 (0.6–1.3)	0.41	0.9 (0.6–1.2)	0.34
Male	1.3 (0.9–1.7)	0.75	1.1 (0.8–1.4)	0.67
BMI	1.0 (0.8–1.2)	0.59	0.8 (0.6–1.1)	0.34
CPB time	0.6 (0.4–0.9)	0.02	0.8 (0.6–1.3)	0.29

HR: hazard ratio; p: p-value; BMI: body mass index; CPB: cardiopulmonary bypass; MV: mechanical ventilation.

Fernandez-Zamora et al.⁶ observed in their study that the mortality rate was higher in patients who remained on MV for a longer time. This finding is explained by the fact that these patients are more susceptible to sepsis and multiple organ failure. Suarez's study also reinforces this finding.⁷

A study of individuals who had undergone cardiac surgery showed that CPB time is a predictor of prolonged MV. Once it is associated with physiological changes, CPB can generate a systematic inflammatory response and increased capillary permeability, which can lead to pulmonary edema, contributing to prolonged MV.⁸

In our study, prolonged MV of more than eight hours was associated with CPB time. Unlike our investigation and the aforementioned ones, Parmana et al.⁹ assessed the duration of MV in patients who underwent off-pump myocardial revascularization. These authors observed that patients also remained on MV for prolonged periods of time. Despite not having CPB, which is a resource responsible for promoting an inflammatory response, other factors were evaluated and found to be predictors of prolonged ventilation. Some of them were high tidal volume, use of inotropic agents, and lungs inflammation.

García-Delgado et al.¹⁰ also concluded that high tidal volume is associated with prolonged ventilation since the volume is capable of generating inflammatory mediators, which in turn, promote biotrauma. The authors also considered that age and female gender were predictors of prolonged ventilation. With regard to gender, their study is in controversy with ours, where males were considered to be predictors of prolonged MV.

Bartz et al.¹¹ also stated in their study of patients who underwent myocardial revascularization that MV was associated with mortality. He pointed to CPB and age as triggering factors.

In terms of age, the present study showed a significant association between this factor and prolonged MV. Sankar et al.⁸ showed in their work that there was longer ventilation in the participants who were in the highest age group. This result is similar to that found by Rahimi et al.,¹² who explained that the ageing process brings structural and functional changes. This is because one of the risk factors for cardiovascular disease is advancing age, which makes this public vulnerable to the onset of hypertension, obesity, dyslipidemia, and other diseases that can increase this risk. In addition, lifestyle habits such as sedentary lifestyles, smoking, and alcohol consumption contribute to the morbidity and mortality of these elderly people.

In the study by Gumus et al.,¹³ there was no correlation between age and gender and prolonged MV, and the authors themselves stated that this result was due to the small number of participants compared to other studies. In contrast, the work by Aksoy et al.¹⁴ emphasized that female gender was a predictor of prolonged MV.

Although Sankar et al.⁸ presented significant results regarding the main causes of mortality after cardiac surgery related to CPB increasing the time on MV, due to inflammatory responses, Bignami et al.¹⁵ emphasized how pulmonary lesions were recurrent in the postoperative period consequently making them susceptible to mortality.

Ball et al.¹⁶ discussed pulmonary complications. Although there is still no definition of these consequences in the postoperative period, they may be associated with the duration and type of surgery, also taking into account the patient's existing predispositions.

The findings of the present research will justify its clinical and scientific relevance. They will also serve as a basis for other works and contribute as a source of information for other students and others interested in the hospital area.

The limitations of this study involve factors that were not assessed, such as high tidal volume, the use of inotropes, and pulmonary inflammation, which could have influenced the results. Furthermore, the absence of an evaluation of pre-existing frailty status is a significant limitation, as frailty is a well-established prognostic factor, particularly concerning mortality and functional recovery in critically ill patients. A more comprehensive discussion of the clinical implications could be improved by considering these factors, as well as incorporating strategies such as early mobilization, sedation protocols, and adjunctive therapies, including anti-inflammatory drugs. These elements might not only affect extubation success but also influence post-ICU recovery and long-term quality of life. A deeper analysis of these variables would provide a more nuanced understanding of critical care management and enhance therapeutic strategies. The small number of patients is another limitation of the study.

An innovative approach to analyzing the relationship between MV time and mortality after coronary artery bypass grafting could involve combining predictive modeling, risk stratification, and conducting multicenter cohort studies. By developing advanced statistical models, such as machine learning, it is possible to identify predictive factors that influence both prolonged ventilation and mortality outcomes, allowing for personalized postoperative care. At the same time, stratifying patients based on

demographic characteristics and comorbidities would help identify at-risk subgroups, guiding more targeted interventions. Finally, conducting a multicenter study would broaden the diversity of the collected data, enabling comparisons between different clinical practices and their respective associations with MV outcomes and mortality, providing a more comprehensive view of the issue.

Conclusion

Based on what was found in the studies analyzed, MV time of more than eight hours is a predictor of mortality after heart surgery given that some risk factors contribute to patients remaining on MV for longer.

Author Contributions

Conception and design of the research, analysis and interpretation of the data, statistical analysis and critical revision of the manuscript for intellectual content: Cordeiro ALL; acquisition of data and writing of the manuscript: Dezidério TLA, Silva VO, Macedo VN.

References

1. Elmiro GS, Souza AH, Loyola SO, Prudente ML, Kushida CL, Carvalho JO, et al. Spinal Anesthesia Increases the Frequency of Extubation in the Operating Room and Decreases the Time of Mechanical Ventilation after Cardiac Surgery. *Braz J Cardiovasc Surg.* 2021;36(1):32-8. doi: 10.21470/1678-9741-2019-0433.
2. LaPar DJ, Gillen JR, Crosby IK, Sawyer RG, Lau CL, Kron IL, et al. Predictors of Operative Mortality in Cardiac Surgical Patients with Prolonged Intensive Care Unit Duration. *J Am Coll Surg.* 2013;216(6):1116-23. doi: 10.1016/j.jamcollsurg.2013.02.028.
3. Mathis MR, Duggal NM, Likosky DS, Haft JW, Douville NJ, Vaughn MT, et al. Intraoperative Mechanical Ventilation and Postoperative Pulmonary Complications after Cardiac Surgery. *Anesthesiology.* 2019;131(5):1046-62. doi: 10.1097/ALN.0000000000002909.
4. Fonseca L, Vieira FN, Azzolin KO. Factors Associated to the Length of Time on Mechanical Ventilation in the Postoperative Period of Cardiac Surgery. *Rev Gaucha Enferm.* 2014;35(2):67-72. doi: 10.1590/1983-1447.2014.02.44697.
5. Kramer AA, Zimmerman JE. Predicting Outcomes for Cardiac Surgery Patients after Intensive Care Unit Admission. *Semin Cardiothorac Vasc Anesth.* 2008;12(3):175-83. doi: 10.1177/1089253208323413.
6. Fernandez-Zamora MD, Gordillo-Brenes A, Banderas-Bravo E, Arboleda-Sánchez JA, Hinojosa-Pérez R, Aguilar-Alonso E, et al. Prolonged Mechanical Ventilation as a Predictor of Mortality after Cardiac Surgery. *Respir Care.* 2018;63(5):550-7. doi: 10.4187/respcare.04915.
7. Suarez-Pierre A, Fraser CD, Zhou X, Crawford TC, Lui C, Metkus TS, et al. Predictors of Operative Mortality Among Cardiac Surgery Patients with Prolonged Ventilation. *J Card Surg.* 2019;34(9):759-66. doi: 10.1111/jocs.14118.
8. Sankar A, Rotstein AJ, Teja B, Carrier FM, Belley-Côté EP, Bolliger D, et al. Prolonged Mechanical Ventilation after Cardiac Surgery: Substudy of the Transfusion Requirements in Cardiac Surgery III Trial. *Can J Anaesth.* 2022;69(12):1493-506. doi: 10.1007/s12630-022-02319-9.
9. Parmana IMA, Boom CE, Poernomo H, Gani C, Nugroho B, Cintyandy R, et al. Systemic Immune-Inflammation Index Predicts Prolonged Mechanical Ventilation and Intensive Care Unit Stay after off-Pump Coronary Artery Bypass Graft Surgery: A Single-Center Retrospective Study. *Vasc Health Risk Manag.* 2023;19:353-61. doi: 10.2147/VHRM.S409678.
10. García-Delgado M, Navarrete-Sánchez I, Colmenero M. Preventing and Managing Perioperative Pulmonary Complications Following Cardiac Surgery. *Curr Opin Anaesthesiol.* 2014;27(2):146-52. doi: 10.1097/ACO.000000000000059.
11. Bartz RR, Ferreira RG, Schroder JN, Davies J, Liu WW, Camara A, et al. Prolonged Pulmonary Support after Cardiac Surgery: Incidence, Risk Factors and Outcomes: A Retrospective Cohort Study. *J Crit Care.* 2015;30(5):940-4. doi: 10.1016/j.jcrc.2015.04.125.
12. Rahimi S, Abdi A, Salari N, Shohaimi S, Naghibeiranvand M. Factors Associated with Long-Term Mechanical Ventilation in Patients Undergoing Cardiovascular Surgery. *BMC Cardiovasc Disord.* 2023;23(1):276. doi: 10.1186/s12872-023-03315-7.
13. Gumus F, Polat A, Yektas A, Totoz T, Bagci M, Erentug V, et al. Prolonged Mechanical Ventilation after CABG: Risk Factor Analysis. *J Cardiothorac Vasc Anesth.* 2015;29(1):52-8. doi: 10.1053/j.jvca.2014.09.002.
14. Aksoy R, Karakoc AZ, Cevirme D, Elibol A, Yigit F, Yilmaz Ü, et al. Predictive Factors of Prolonged Ventilation Following Cardiac Surgery with Cardiopulmonary Bypass. *Braz J Cardiovasc Surg.* 2021;36(6):780-7. doi: 10.21470/1678-9741-2020-0164.
15. Bignami E, Guarnieri M, Giambuzzi I, Trumello C, Saglietti F, Gianni S, et al. Three Logistic Predictive Models for the Prediction of Mortality and Major Pulmonary Complications after Cardiac Surgery. *Medicina.* 2023;59(8):1368. doi: 10.3390/medicina59081368.
16. Ball L, Costantino F, Pelosi P. Postoperative Complications of Patients Undergoing Cardiac Surgery. *Curr Opin Crit Care.* 2016;22(4):386-92. doi: 10.1097/MCC.0000000000000319.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Centro Universitário Nobre under the protocol number 853.947. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.



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