

Protocol For Weaning From Mechanical Ventilation in Patients Undergoing Coronary Artery Bypass Grafting: Cohort Study

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Abstract

Background: Patients with heart disease often require mechanical ventilation (MV). Although weaning protocols may reduce the duration of MV, the literature presents contradictory findings regarding their effectiveness, and there is a lack of studies specifically involving cardiac patients.

Objective: To evaluate whether a weaning protocol reduces the duration of MV compared with weaning based on clinical judgment in cardiac patients.

Methods: A retrospective cohort study was conducted with patients undergoing myocardial revascularization. They were randomly assigned to either the protocol-driven (intervention) group or the conventional weaning group. Weaning time, MV duration, and length of stay in the Intensive Care Unit (ICU) were assessed. Comparisons between groups were performed using the unpaired Student's t-test. A p-value <0.05 was considered statistically significant.

Results: A total of 214 patients were evaluated. The mean duration of MV was shorter in the intervention group (4 vs. 9 hours, $p < 0.001$). The mean ICU length of stay was 2 vs. 5 days in the intervention and control groups, respectively ($p = 0.02$).

Conclusion: The findings suggest that protocol-guided weaning may be associated with reductions in weaning time, duration of MV, and ICU length of stay, raising the hypothesis of a potential clinical benefit that warrants further investigation in future studies.

Keywords: Clinical Protocols; Artificial Respiration; Intensive Care Units.

Introduction

The use of mechanical ventilation (MV) in patients with heart disease is frequent, especially among those undergoing cardiac surgery.^{1,2} This highlights the need for increasingly efficient ventilatory weaning protocols to reduce complications associated with prolonged MV.³ Several factors are essential when developing and applying protocols for mechanically ventilated cardiac patients, as careful monitoring and targeted interventions help optimize therapy and improve clinical outcomes.^{3,4} Conditions such as acute or chronic decompensated heart failure and cardiac surgery often lead to the need for MV in this population.⁵

In patients undergoing cardiac surgery, MV is essential due to reduced levels of consciousness caused by general anesthesia, as well as postoperative impairment of lung function.⁶ However, despite its importance, MV can lead to significant postoperative complications.⁷ When rapid and early weaning does not occur, the risk of ventilator-associated or hospital-acquired pneumonia and lung tissue injury increases.¹

Evidence on the application of MV weaning protocols also appears in other patient populations beyond those with heart disease. In adult patients, the implementation of a ventilatory weaning protocol improved the overall quality of the process, facilitating the identification of individuals who met the criteria to begin weaning. This allowed weaning to start earlier and resulted in a reduction in total weaning time.⁸ In neurocritical patients, the use of a structured protocol led to high extubation rates, a reduced need for tracheostomy, and a shorter duration of MV.⁹

The application of protocols specifically aimed at weaning patients undergoing cardiac surgery is more limited in the scientific literature compared with other patient groups. Due to the scarcity of evidence in this context, the present study seeks to address this gap by contributing

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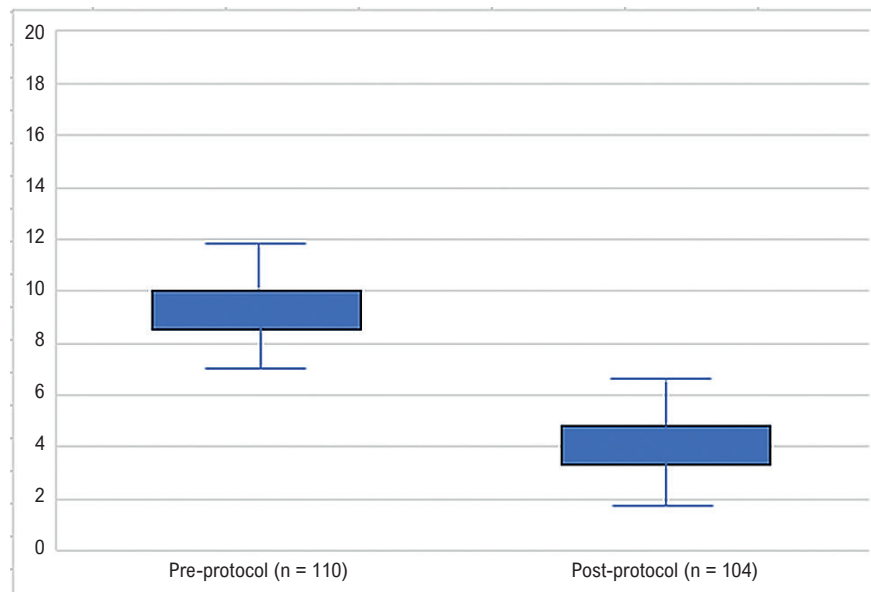
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Central Illustration: Protocol For Weaning From Mechanical Ventilation in Patients Undergoing Coronary Artery Bypass Grafting: Cohort Study

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Mechanical ventilation time in the pre- and post-protocol periods

to the development of strategies that improve the process of discontinuing ventilatory support. The goal is to reduce ventilation time and the associated risks that may arise when patients remain on MV for prolonged periods. Therefore, this study aims to evaluate whether a structured weaning protocol reduces the duration of MV compared with weaning based solely on clinical judgment in patients with heart disease.

Methods

Study design

This is a cohort study conducted with patients undergoing myocardial revascularization at a cardiology referral hospital in the interior of Bahia, between 2019 and 2021.

Inclusion and exclusion criteria

The inclusion criteria for early extubation during the study period were: patients undergoing coronary artery bypass grafting via median sternotomy and cardiopulmonary bypass, aged over 18 years, of either sex. According to their clinical presentation, patients were categorized as having acute coronary syndrome – including unstable angina, non-ST-elevation myocardial infarction, or ST-elevation myocardial infarction – or stable coronary artery disease. Patients were excluded if they were not eligible for early extubation; if they required advanced circulatory support other than an intra-aortic balloon pump (IABP); if they required inhaled pulmonary vasodilators; if

they had an open chest; if they presented significant lactic acidosis (lactate >4 mmol/L after admission or >6 mmol/L after January 2020 with bicarbonate <18 mmol/L); or if they had continuous bleeding (>200 mL/h in the first postoperative hour).

Outcomes

The primary outcome was time to weaning. Secondary outcomes included duration of MV, length of stay in the intensive care unit (ICU), and total hospital length of stay.

Study protocol

Baseline characteristics were collected from patient records and included age, sex, race, and body mass index. Patient comorbidities included a history of hypertension, congestive heart failure, coronary artery disease, previous cardiac surgery, chronic pulmonary disease, cerebrovascular disease, peripheral vascular disease, chronic kidney disease, and diabetes mellitus. Intraoperative variables included procedure type and urgency (elective vs. urgent/emergency), use of an intra-aortic balloon pump (IABP), and cardiopulmonary bypass time.

Myocardial revascularization surgery was performed using a standard technique through a median sternotomy with cardiopulmonary bypass. In all patients, one or more saphenous veins were used for grafting. Additionally, all patients received an internal mammary artery graft.

Postoperatively, all patients received analgesic therapy with piritramide, an opioid derivative. No sedative

medications were administered. Cardiovascular support medications included dopamine, dobutamine, nitroglycerin, isoproterenol, and norepinephrine, all given according to standard practice.

The study was conducted over two years. In the first year, no formal weaning protocol had been established. Patients in this group were managed according to routine hospital practice. Upon arrival in the ICU, they were placed on MV in volume-controlled assist mode. Once they demonstrated sustained interaction with the ventilator, the mode was switched to pressure support. A spontaneous breathing trial was then performed, and if successful, the patient was extubated and transitioned to low-flow oxygen therapy.

In the second year, a structured weaning protocol was implemented, consisting of the following steps: (1) education provided to intensivists, nursing staff, physiotherapists, and intraoperative anesthesiologists regarding the goals of the protocol; (2) obtaining a preoperative baseline arterial blood gas analysis; (3) encouraging intraoperative anesthesiologists to use dexmedetomidine for sedation and analgesia at the end of the procedure and to reverse neuromuscular blockade before completion of surgery; (4) placing a red sign on each patient's ventilator indicating the target extubation time; (5) staff education on sedation weaning while ensuring patient comfort; (6) liberalization of the previous ventilator weaning protocol, specifically accelerating reductions in FiO_2 and positive end-expiratory pressure, advancing more rapidly to spontaneous breathing trials, and broadening the acceptable blood gas parameters for extubation. This protocol was based on the study by Richey et al.¹⁰

If a patient was included in the protocol group, the physiotherapist initiated the spontaneous breathing trial as soon as the patient began to respond. The patient was extubated 20 to 30 minutes after successfully completing the spontaneous breathing trial.

Statistical analysis

All patients were analyzed according to the intention-to-treat principle. The Kolmogorov–Smirnov test was used to assess normality. For continuous variables, the mean $\pm$ standard deviation (SD) was calculated. Categorical variables were presented as absolute and relative frequencies. Comparisons between the two groups were performed using the Student's *t*-test for independent samples for continuous variables and the chi-square test for categorical variables. All statistical analyses were conducted using SPSS version 21.0. A *p*-value <0.05 was considered statistically significant.

Results

A total of 256 eligible participants were identified, of whom 42 were excluded – 22 in the first year and 20 in the second year – resulting in a final sample of 214 patients. The mean age was 56 ± 5 years, with a predominance of males (151 patients, 71%). A sedentary lifestyle was the most common comorbidity in the pre-protocol group, affecting 82 patients (75%), whereas in the post-protocol group,

systemic arterial hypertension (SAH) was the most prevalent comorbidity, present in 78 patients (75%). Additional data are presented in Table 1.

Table 2 presents the outcomes associated with the implementation of the weaning protocol, highlighting the duration of MV ($p < 0.001$), ICU length of stay ($p = 0.02$), and hospital length of stay ($p = 0.03$), all of which showed statistically significant differences between the periods analyzed. The primary outcome – duration of MV – is illustrated in the central figure comparing the pre- and post-protocol groups.

Discussion

The present study aimed to evaluate whether the implementation of a weaning protocol reduces the duration of MV compared with weaning based solely on clinical judgment in patients undergoing cardiac surgery. After analyzing the results, we found that the implementation of the protocol significantly reduced MV duration, ICU length of stay, and overall hospital length of stay.

The study by Yang-Han Lin et al.,⁵ which evaluated outcomes achieved through the implementation of a ventilatory weaning protocol integrated with artificial intelligence, reported results similar to ours, demonstrating significant reductions in hospital stay, ICU stay, and MV duration. These improvements are largely attributed to the systematization of procedures, which guides clinical approaches and interventions in a more direct, objective, and consistent manner.¹¹ Protocol-driven measures minimize variability in clinical interpretation and judgment, ensuring that all team members follow standardized actions focused on the primary goal: promoting faster and more efficient ventilatory weaning, as recommended in the literature.^{12,13}

The duration of MV is a key component in the care of patients undergoing cardiac surgery.¹⁴ Xie et al.¹⁵ highlight the challenges associated with weaning mechanically ventilated patients, particularly after complex surgical procedures. Effective ventilatory weaning is associated with improved recovery and survival rates. Conversely, prolonged MV and weaning failure contribute to increased hospital length of stay, morbidity, and mortality. Therefore, identifying variables that influence MV duration is essential to reducing the likelihood of weaning failure.^{16,17} Such identification and clinical decision-making can be strengthened through the development and implementation of well-designed, evidence-based protocols.

The period of stay in the ICU and hospital reveals that the implementation of the protocol suggested improving patient recovery in a more agile and effective way. Important reduction in the length of stay in the ICU and hospital shows that the procedure helps to remove ventilatory support more safely and quickly, speeding up the transfer to less intensive care.¹⁸ Furthermore, shorter hospital stays bring significant economic advantages, alleviating the demand for hospital resources and reducing the costs of prolonged treatment. However, it is essential to take into account the diversity of samples analyzed and unregulated factors that

Table 1 – Clinical and surgical characteristics of the patients studied

Variables	Pre-protocol (n = 110)	Post-protocol (n = 104)	p
Age (years)	57 ± 5	55 ± 4	0.45 ^a
Gender			
Male	79 (72%)	72 (69%)	0.82 ^b
Female	31 (28%)	32 (31%)	
Body Mass Index (kg/m ²)	26 ± 2	27 ± 3	0.75 ^a
Comorbidities			
Diabetes Mellitus	55 (50%)	61 (58%)	0.58 ^b
Systemic Arterial Hypertension	76 (69%)	78 (75%)	
Dyslipidemia	47 (43%)	44 (42%)	
Sedentary lifestyle	82 (75%)	76 (73%)	
Cardiopulmonary bypass time (min)	88 ± 5	83 ± 4	0.49 ^a
Number of grafts	2 ± 1	2 ± 1	0.91 ^a
Number of drains	2 ± 1	2 ± 1	0.94 ^a

a. Student's *t*-test for independent samples; b. Chi-square test

Table 2 – Outcomes associated with the protocol implementation

Variables	Pre-protocol (n = 110)	Post-protocol (n = 104)	p
MV time (hours)	9 ± 2	4 ± 2	<0.001 ^a
Length of stay in the ICU (days)	5 ± 3	2 ± 2	0.02 ^a
Length of hospital stay (days)	15 ± 5	9 ± 3	0.03 ^a
Hospital mortality	12 (11%)	5 (5%)	0.06
ARDS	7 (58%)	3 (60%)	
Sepsis	5 (42%)	2 (40%)	
Reintubation	11 (10%)	9 (9%)	0.78
Atrial Fibrillation	8 (7%)	6 (6%)	0.87

MV: mechanical ventilation; ARDS: acute respiratory distress syndrome; ICU: Intensive Care Unit; a. Student's *t*-test for independent samples; b. Chi-square

can impact the results, such as the severity of the heart problem and the existence of other comorbidities, which can directly impact the length of stay in hospital.

According to research carried out by Trudzinski et al.,¹⁹ prolonged MV, together with failure to wean, are the biggest risks that increase the mortality rate of patients. This failure may be indicative of serious underlying conditions such as respiratory muscle weakness, heart failure, or other organ dysfunction. The mortality rate associated with the weaning protocol may vary depending on several factors, including the patient's underlying condition, duration of MV, the presence of comorbidities, and the effectiveness of the implemented weaning protocol.²⁰

Although the protocol showed that there was an improvement in outcomes such as duration of MV, length of stay in the ICU and hospital stay, the reintubation rate did not

show a significant difference. This result may be associated with some factors that lead to the need to reintubate these patients. In a study by Xie et al.,²¹ they showed that patients with a physical status classification greater than or equal to three, chronic obstructive pulmonary disease, thoracic surgery, airway surgery, head and neck surgery, sepsis and deep vein thrombosis are related to the reintubation of postoperative patients. The reintubation procedure can generate complications leading to increased post-surgery hospital stay, mortality and pneumonia associated with MV, which can negatively impact the patient's recovery.²²

This study had several limitations. These include the absence of a sample size calculation, the lack of preoperative pulmonary function testing, and the omission of variables such as the rapid shallow breathing index and respiratory muscle strength, which prevented the identification

of potential differences in respiratory capacity between groups. Additionally, the study was conducted in a single hospital, which may limit the generalizability of the findings.

Conclusion

The findings suggest that protocol-guided weaning may be associated with reductions in weaning time, duration of MV, and ICU length of stay, raising the hypothesis of a potential clinical benefit that warrants further investigation in future studies.

Author Contributions

Conception and design of the research, acquisition of data, analysis and interpretation of the data and writing of the manuscript: Cordeiro ALL, Lopes WFS, Jesus TC, Oliveira AJG, Coutinho ACO; statistical analysis: Cordeiro ALL; critical revision of the manuscript for intellectual content: Lopes WFS, Guimarães ARE.

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 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.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

The underlying content of the research text is contained within the manuscript.

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