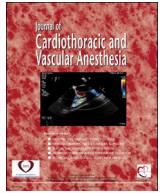




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## Original Article

# Implementation of an Early Extubation Protocol in Cardiac Surgical Patients Decreased Ventilator Time But Not Intensive Care Unit or Hospital Length of Stay

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**Objective:** The optimal timing of extubation following cardiac surgery is currently unknown. Protocols implemented in order to achieve a rapid extubation may achieve this goal, but not prove beneficial in terms of outcomes.

**Design:** A prospective clinical trial.

**Setting:** Tertiary care cardiac surgical intensive care unit.

**Participants:** Adult cardiac surgical patients.

**Interventions:** Implementation of an 8-tier multidisciplinary rapid weaning protocol.

**Measurements and Main Results:** Ventilator times 6 months prior to and 6 months after implementation of the protocol were measured. Outcomes associated with ventilator times were measured by dividing the patients into tertiles (< 6 hours, 6-12 hours, > 12 hours). Primary outcomes were intensive care unit (ICU) and hospital length of stay. Secondary outcomes included mortality at 30 days and other major morbidities.

In all, 459 patients were included in the study. With implementation of the protocol, median ventilation times decreased from 7.4 hours (interquartile range, IQR = 3rd quartile – 1st quartile = 6.72 hours) to 5.73 hours (IQR = 5.51 hours) ( $p < 0.0001$ ). However, median ICU length of stay in patients who achieved extubation within 6 hours increased to 49.45 hours (IQR = 44.4) from 40.3 (IQR = 25.6) ( $p = 0.0017$ ). Median hospital length of stay was not significantly changed due to the protocol in any ventilation tertile ( $p = 0.650$ ).

**Conclusions:** Decreasing intubation times to < 6 hours in postsurgical cardiac patients is obtainable with implementation of a multidisciplinary rapid weaning protocol. However, patients extubated within 6 hours had increased ICU length of stay and no difference in hospital length of stay with this intervention.

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**Key Words:** fast-track cardiac surgery; rapid weaning protocol; cardiac intensive care unit; extubation; cardiac surgery; length of stay

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PRIOR TO the 1990's, cardiac surgical patients commonly stayed intubated overnight to avoid increased myocardial oxygen demands and stress response following surgery.<sup>1,2</sup> Since then, "fast-track" cardiac surgery with a focus on early

extubation has had numerous publications showing beneficial results such as a decrease in rates of pneumonia, sepsis, reintubations, costs, and intensive care unit (ICU) and hospital lengths of stay.<sup>1-6</sup> Currently, the Society of Thoracic Surgeons (STS) identifies tracheal extubation following cardiac surgery in less than 6 hours as a marker of quality.<sup>7</sup>

However, a recent meta-analysis of 28 trials concerning “fast-track” cardiac surgery found no difference in mortality and major postoperative complications in patients on the “fast track” and those extubated later.<sup>1</sup> Another recent report found that patients extubated within 12 hours following cardiac surgery had similar risk of mortality, major complications, and prolonged hospital length of stay as patients who were extubated in < 6 hours.<sup>8</sup>

There is also much discrepancy concerning what defines “fast-track” cardiac surgery, especially among older publications. Additionally, as the decades change so do case mix indices and procedures. Contemporary thinking may conclude that morbidities associated with prolonged ventilation following cardiac surgery are not due to the act of ventilation, but are a reflection of the case mix of patients who remain intubated for prolonged periods. With these questions in mind, the authors initiated a multidisciplinary protocol in postoperative cardiac surgical ICU patients with the goal of ventilator liberation in < 6 hours after departure from the operating room. The authors analyzed the success of the protocol intervention and also effects on ICU and hospital lengths of stay and other major morbidities in reference to ventilator time.

## Methods

After obtaining a waiver of institutional review board approval due to the quality improvement nature of the study, the author prospectively analyzed time to extubation in 459 postoperative cardiothoracic surgical ICU patients prior to and after initiation of a protocol aimed at achieving extubation within 6 hours. The 2 sequential time periods were 6 months each. Ventilation hours were divided into tertiles of < 6 hours, 6 to 12 hours, and > 12 hours. A total of 246 patients had cardiac surgery during the 6 months prior to the protocol interventions, and 213 patients had cardiac surgery during the 6 months post-protocol intervention. The authors also analyzed the associated ICU length of stay and hospital length of stay during the 2 time periods both in relation to the protocol and in relation to ventilator time. Secondary outcomes included 30-day mortality, reintubations, postoperative renal failure, sternal wound infections, postoperative strokes, postoperative cardiac arrest, and reoperation for any cardiac reason.

Patient demographics collected included procedure type, STS-predicted morbidity or mortality score, emergent/urgent surgery, cardiopulmonary bypass time, hypertension, chronic lung disease defined as a preoperative forced expired volume in 1 second < 75% or on chronic inhaled, oral bronchodilator or oral steroid therapy, diabetes defined as a history of diabetes diagnosis or a preoperative hemoglobin A1c  $\geq$  6.5%, preoperative atrial fibrillation, preoperative systolic heart failure,

body mass index (BMI), preoperative cardiogenic shock, and/or presence of a preoperative intra-aortic balloon pump. Procedures were stratified as isolated CABG, isolated valve procedure, CABG + valve(s), aortic procedure for aortic root, and ascending repairs and other procedures. Patients receiving a ventricular assist device, transplantation, transcatheter aortic valve replacement, or endovascular repair were excluded. Preoperative systolic heart failure was defined as an ejection fraction < 50%. Preoperative cardiogenic shock was defined as the need for an inotrope and/or an intra-aortic balloon pump for circulatory support prior to surgery.

The elements of the rapid ventilation weaning protocol were derived by a multidisciplinary group of caregivers who met on a regular basis for approximately 4 months prior to initiation. These meetings allowed for continual communication and protocol modification as each discipline disseminated the protocol in its various stages and educated their providers. The protocol interventions included: (1) education given to intensivists, nursing staff, respiratory therapists, and intraoperative anesthesiologists concerning the goals of the protocol; (2) attainment of a preoperative baseline arterial blood gas (ABG); (3) intraoperative anesthesiologists were encouraged to utilize dexmedetomidine for sedation and analgesia at the end of the case and to reverse paralytic agents; (4) placement of a red sign on each patient's ventilator documenting the goal time of extubation; (5) education of staff on sedation weaning while ensuring patient comfort; (6) liberalization of the previous ventilator weaning protocol, specifically expediting the wean of FiO<sub>2</sub>, positive end-expiratory pressure, progression toward spontaneous breathing trials, and liberalizing ABG extubation parameters (Supplement 1); (7) encouragement of the entire care team to huddle at the 4-hour time mark to address progress; and (8) chart documentation of circumstances precluding a 6-hour extubation if not achieved.

## Statistical Analysis

First, the baseline characteristics for patients pre- and post-protocol implementation were summarized and compared to see if the patient populations were different. Second, the ventilation times pre- and post-protocol were compared to show whether protocol implementation successfully shortened the ventilation time as expected. Due to the highly skewed distribution, the two-sample Wilcoxon rank sum test (Mann-Whitney U test) was used for hypothesis testing. Third, the association of ventilation time and outcomes pre- and post-protocol implementation was examined. For continuous outcomes, such as ICU length of stay and hospital length of stay, the associations with ventilation time categorized in tertiles were analyzed using nonparametric Kruskal-Wallis test; for binary outcomes, the change in event rate pre- and post-protocol was analyzed using Chi-square test, or Fisher's exact tests were used for analyses. For summary statistics, median and interquartile ranges (IQR = 3rd quartile–1st quartile) instead of mean (standard deviation) were used as the ventilation time; ICU and hospital lengths of stay were all highly skewed with outliers.

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