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# Causes of Prolonged Mechanical Ventilation After Coronary Artery Bypass Grafting Surgery

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## Abstract

***Background-*** Coronary artery bypass grafting surgery (CABG) is a commonly performed procedure. More than 10,000 CABG surgery procedures are performed in Iran annually. Prolonged mechanical ventilation following CABG surgery is uncommon. Economic factors have led to a trend for early tracheal extubation after CABG. Fast-track extubation is variously defined but most agree that it refers to extubation within 8 hours.

***Methods-***A descriptive observational study was conducted on 196 patients undergoing CABG surgery. Following surgery, standard weaning protocol was implemented. Patients who failed to be extubated within 8 hrs were evaluated.

***Results-*** Four patients (2.04%) died within 3 to 12 days. After undergoing surgery, the minimum duration of mechanical ventilation was 2 hrs, up to a maximum duration of 19 days. 94.3% of the patients were extubated within 24 hrs, with a mean duration of 9.54 hrs. 5.7% of the patients were still intubated after 24h. The most common cause of delayed extubation was physician trend (n=27, 13.8% of patients). Reduced ejection fraction, EKG changes, elderly age, prolonged CPB, difficult intubation were reasons for this trend. The second most common cause was excessive postoperative bleeding, which occurred in 13.3% of the patients. Four percent of the patients were returned to the operating room for re-exploration. Cardiovascular instability (11.7%), metabolic acidosis (9.7%), prolonged recovery (4.7%), neurologic problems (2%), poor FVC (4.6%), hypoxemia (1.5%), and acute respiratory distress syndrome (ARDS) (0.5%) were other reasons.

***Conclusion-*** The incidence of prolonged mechanical ventilation for more than 24h was similar to that of the STS database.[8] We found the most common cause of delayed extubation to be physician trend. We recommend changing our strategy in these patients. Excessive postoperative bleeding incidence in our study was slightly higher than that in other studies. We found the proportion of patients with failure to extubate due to various reasons would vary from institution to institution, based on differences in patient population and management strategies***(Iranian Heart Journal 2008; 9 (1):47 -54).***

**Key words**: coronary artery bypass grafting surgery ■ prolonged mechanical ventilation

Coronary artery bypass grafting surgery (CABG) is today a commonly performed procedure and the complication rate is generally low.

Received Apr, 21 2006; Accepted for publication Apr 24, 2008.
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Although prolonged mechanical ventilation following cardiac surgery is uncommon, it can significantly decrease the quality of life and increase overall hospital costs.[1]

Economic considerations have led to a trend for early tracheal extubation after cardiac surgery. Early tracheal extubation reduces total costs of CABG by 25%, predominantly in nursing and intensive care unit costs.[2]

Postoperative respiratory management is an essential component in the care of cardiac surgical patients because the anesthetics, surgical and cardiopulmonary bypass (CPB) procedures have transient deleterious effects on pulmonary function. Acute restrictive pulmonary deficits will be the result of these insults.[3]

Fast-track or early extubation following cardiac surgery is variously defined, but most agree that extubation within 8 hours qualifies as such. The impetus for fast-track anesthesia is primarily economic.[4] We sought to determine the exact cause of the need for prolonged mechanical ventilation in our center.

Therefore, we undertook a prospective observational study to identify and compare the causes of prolonged mechanical ventilation (after 8 hrs) post- CABG surgery. More than 10,000 CABG surgical procedures are performed in our country annually.

## Methods

A descriptive, observational study was conducted at our center from November to December 2005. The human ethics committee of the center approved the study protocol.

### Patient population

All patients undergoing traditional CABG surgery (on-pump or off-pump) were included in the study. Patients undergoing valve replacement were excluded. Patients were selected prior to surgery or at admission to the ICU following surgery.

### Weaning protocol

Following CABG surgery, weaning protocol was performed for all the patients (Fig. 1).

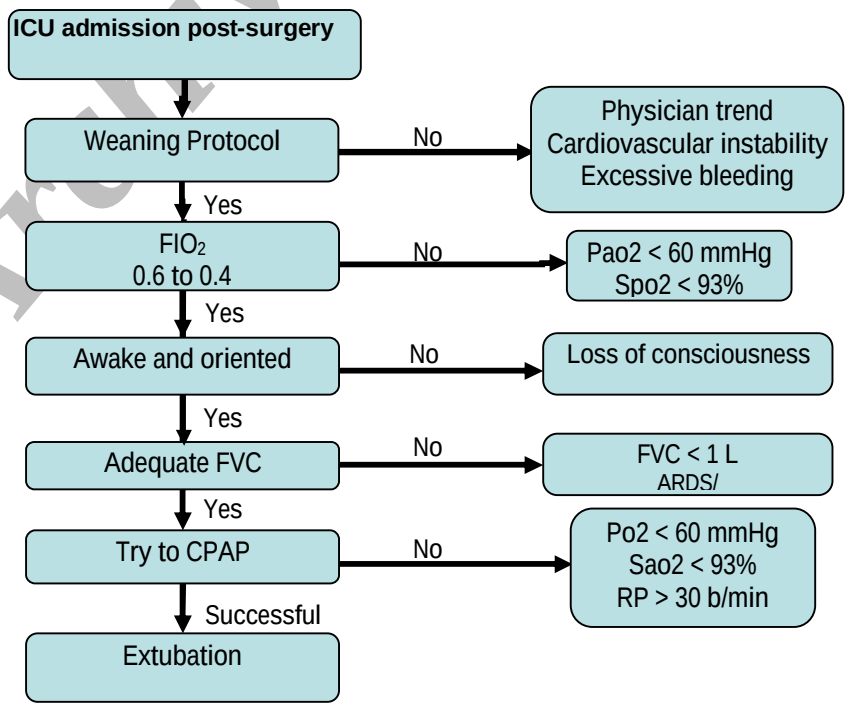


**Fig. I.** Weaning protocol

After arrival at the ICU, the fraction of inspired oxygen ($FIO_2$) of 0.6 was delivered. It was then decreased to 0.4 if oxygen saturation was maintained more than 93%. Once the $FIO_2$ goal was achieved, the level of consciousness and forced vital capacity FVC) were evaluated in all the patients.

The patients who were alert and had an FVC>1 L were switched from assist/control mode to continuous positive airway pressure (CPAP) mode. The patients were extubated if a blood gas measurement after 30 min. was satisfactory. If the patients failed to achieve these parameters, the study physician was called and subsequent weaning attempts were continued based on specific orders.

The reasons for failure to extubation and the definitions of causes were determined before the commencement of the study (Table I).

**Table I. Reasons for failure to extubation**

| Reasons | Definition | Causes |
|---|---|---|
| **1) Depressed level of consciousness** | Inability to arouse | **Residual anesthesia neurologic lesions** |
| **2) Hypoxemia** | Pao2 < 60 mmHg Sao2 < 93% | **Fig. 2** |
| **3) Increased respiratory rate** | RR > 30 b/min | **metabolic acidosis respiratory alkalosis mixed acid-base** |
| **4) Cardiovascular instability** | SBP > 180 mmHg or SBP < 90 mmHg Significant arrhythmias | |
| **5) Excessive postoperative bleeding** | More than 100 ml/hr for 3 consecutive hours | |
| **6) Inadequate forced vital capacity (FVC)** | **FVC < 1L** | |

Reduced level of consciousness, hypoxemia, cardiovascular instability, poor FVC, excessive postoperative bleeding, and finally physician trend were the main reasons. The patients with hypoxemia with normal or near normal chest radiograph findings and no apparent reason for hypoxemia were termed as hypoxemia of unknown etiology. Near normal findings included abnormalities such as pleural effusion or plate-like atelectasis.

The most commonly used general anesthetic agents were midazolam, sufentanil, and atracurium.

**Data collection**

Preoperative patient characteristics, as well as perioperative and postoperative complications were recorded for all the patients by the study physician. The patients were called via telephone 30 days after ICU discharge to determine the presence of any complication or death.

**Statistical analysis**

Based on our study (descriptive observational study), the statistical analyses were as a form of frequencies and ratios.

## Results

One hundred ninety-six patients were prospectively enrolled into the study. Four patients (2.04%) died within 30 days after undergoing CABG surgery. These 4 patients died within 3 up to 12 days after undergoing surgery. All of these 4 patients were never extubated, and all of them were weaned from cardiopulmonary bypass with difficulty and use of inotropic agents and insertion of intra-aortic balloon pump. The baseline patient characteristics are summarized in Table II.

Among the surviving patients, the minimum duration of mechanical ventilation via endotracheal tube was 2 hrs and maximum ventilatory support was 19 days, just for one patient.

Ninety-five patients (48.5%) were extubated within the first 8hrs following CABG surgery (group A). Ninety patients (45.8%, Group B), 5 patients (2.6%, Group C), and 6 patients (3.1%, Group D) were also extubated from

8hrs to 24 hrs, 24 hrs to 48hrs, and after 48 hrs, respectively (Table III).

**Table II. Patients' characteristics**

| Characteristics | Value |
|---|---|
| Age (year) | 58.0269.54 |
| Female | 54 (27.6%) |
| Smoker | 49 (25%) |
| Diabetics | 65 (33.2%) |
| Renal failure | 7 (3.6%) |
| Chronic lung disease | 22 (11.2%) |
| **Number of grafts** | |
| One | 4 (2%) |
| Two | 39 (19.9%) |
| Three | 86 (43.9%) |
| Four | 61 (31.1%) |
| Five | 6 (3.1%) |
| Ejection Fraction | 43.9369.49 |
| Off pump | 19 (9.7%) |
| Emergency | 5 (2.6%) |

**Table III. Endotracheal extubation times**

| Extubation time | | Frequency | Percent |
|---|---|---|---|
| **Group A** | Within 8 h | **95** | **48.5** |
| **Group B** | Beyond 8-24 h | **90** | **45.8** |
| **Group C** | Beyond 24-48 h | **5** | **2.6** |
| **Group D** | Beyond 48 h | **6** | **3.1** |

The overall mean duration of mechanical support among the patients in group A and group B were 6.12 hrs and 12.88 hrs, respectively. Because of approximate ranges of extubation hours, standard deviations were not considered in this study. As a result, the mean duration of mechanical ventilatory support in 185 patients (94.3% of the patients in our study) was 9.54 hrs.

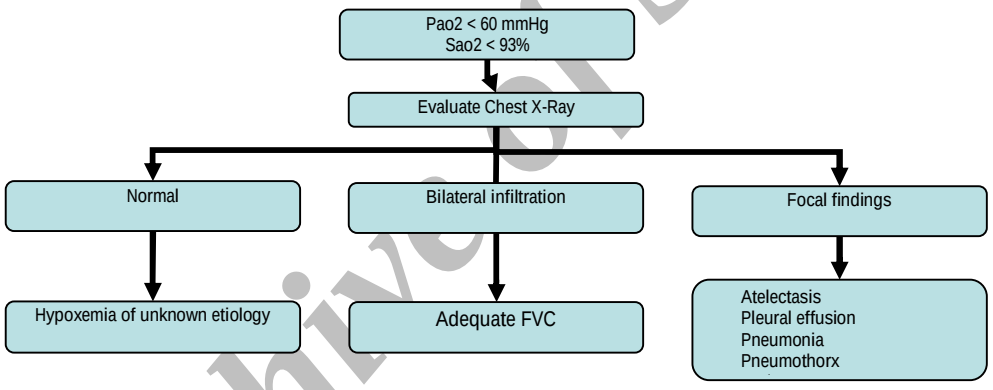


**Fig. 2.** Hypoxemia

Prolonged mechanical ventilation after 24 hrs occurred in 11 patients (5.7%). None of the patients who were successfully extubated was ever reintubated.

Five patients (2.6%) arrived in the operating room in emergency status. Two of these 5 patients, following dissection of the left anterior descending coronary artery, underwent CABG surgery and the rest were due to unstable and unrelenting angina pectoris. After revascularization, they were discharged in good condition.

Nineteen patients underwent CABG surgery with off-pump technique. The mean duration of mechanical support in this group was 7.78 hours, with a minimum of 4 hrs up to a maximum of 14 hrs.

The number of cases of off-pump surgery was low and, therefore, a statistical analysis between on-pump and off-pump groups was not possible in our study.

Seventeen patients (8.7%) were weaned from CPB with the administration of a variety of inotropic agents.

These patients, after the optimization of cardiovascular status and tapering of inotropic agents to low dose, were extubated. Also, 5 patients (2.6%) were weaned from CPB by the insertion of an intra-aortic balloon pump; 4 of these patients died.

Among the patients, the mean duration of cardiopulmonary bypass (CPB) time was 98.64 min with a minimum of 45 min. up to a maximum of 280 min. Most of the patients had 3-vessel disease (43.9%).

ICU stay for the patients was from 2 up to 27 days. Additionally, 158 patients (80.6%) were discharged from the ICU routinely on postoperative day 2, and 10 patients (5.1%) were discharged on postoperative day 1. The rest were discharged based on their condition.

Causes of failure to extubation after CABG surgery were heterogeneous and had a variable impact on the duration of ventilation (Table IV).

**Table IV. Causes of Delayed Extubation**

| Causes | Overall | 8-24 h | 24-48 h | > 48 h |
|---|---|---|---|---|
| Physician trend | 27 (13.8%) | 27 (13.8%) | | |
| Bleeding | 26 (13.3%) | 25 (12.8%) | 1 (0.5%) | |
| Cardiovascular instability | 23 (11.7%) | 14 (7.1%) | 3 (1.5%) | 6 (3.1%) |
| Metabolic acidosis | 19 (9.7%) | 19 (9.7%) | | |
| Inadequate FVC | 9 (4.6%) | 9 (4.6%) | | |
| Residual anesthesia | 8 (4.1%) | 8 (4.8%) | | |
| Neurologic complication | 4 (2%) | 4 (2%) | | |
| Hypoxia | 3 (1.5%) | 3 (1.5%) | | |
| ARDS/ pulmonary edema | 1 (0.5%) | | | 1 (0.5%) |

This study showed that the majority of the patients (94.3%) were extubated during 24 hrs.

The most common cause of delayed extubation in 27 patients (13.8%) was physician trend.

Ejection fraction less than 30% (n=11), prolonged CPB time (n=2), non-significant cardiac arrhythmia (n=3), difficult intubation (n=1), previous history of hypothyroidism (n=1) were among the cited reasons for this trend.

The second common cause of prolonged mechanical ventilation was excessive postoperative bleeding. It occurred in 26 patients (13.3%). Eight of these patients (4.08%) returned to the operating room for re-exploration. The others were treated by medical interventions. All of these patients were extubated within 24 hrs, except for one.

The third common cause of delayed extubation was cardiovascular instability, seen in 23 patients (11.7%).

Following medical intervention, most of the patients were extubated within 24 hrs. After ARDS, cardiovascular instability patients had the longest duration of mechanical ventilatory support.

Metabolic acidosis continued in 19 patients (9.7%) after 8 hrs and was treated according to the underlying causes. All of them were extubated during 24 hrs.

Prolonged recovery from anesthesia was seen in 8 patients (4.1%) for delayed extubation. Within 24 hrs, they were awake and were consequently extubated.

Agitation and delirium due to pain or history of psychosis was present in 4 patients (2%) and resulted in prolonged mechanical ventilation for 24 hrs. Spontaneous breathing trial was not attempted in 9 patients (4.6) due to poor FVC despite normal levels of alertness. Surprisingly, hypoxia itself by our definition was an uncommon reason for delayed extubation.

Hypoxia due to local findings in chest radiograph (hemothorax, atelectasis) occurred in 3 patients (1.5%) and they were extubated within 24 hrs.

Pulmonary edema/ARDS occurred in just one patient (0.5%). This patient had the longest duration of mechanical ventilation (19 days).

Treatment of ARDS was initiated in customary fashion and finally she was successfully extubated on postoperative day 19 and discharged from the ICU 2 days later.

In 19 patients, (9.6%), failure to extubation after 8 hrs following CABG surgery was due to more than one reason.

After 24 hrs, only 11 patients (5.7%) were still intubated. Cardiovascular instability (n=9), bleeding (n=1), and ARDS (n=1) were causes of delayed extubation in this period.

## Discussion

Virtually all patients undergoing open-heart surgery have some element of postoperative pulmonary dysfunction. However, in the vast majority of patients, it is well tolerated with minimal impairment in oxygenation and ventilation. Thus, it is possible and desirable in most patients to achieve early endotracheal extubation within the first 12 hours after surgery. This has been shown in multiple studies to reduce pulmonary complications, encourage earlier mobilization, and shorten the hospital stay.[2,5-7]

Multiple weaning parameters and different times for discontinuation and extubation have been cited in studies, and others have examined the risk factors for prolonged mechanical ventilation after CABG surgery.[1,16] This study is a descriptive analysis of the reasons for failure to extubation after CABG surgery. Our objective was to identify the typical duration of postoperative mechanical ventilation. In our center, extubation is protocol-driven without direct input by clinicians. We set 8, 8-24, 24-48 and more than 48 hours as the cut- offs for delayed extubation.

We tend to discontinue mechanical ventilation and extubate patients within the first 8 hrs following CABG surgery. We attempted to define the mean duration of mechanical ventilatory support in our center.

The mean duration of mechanical ventilation in patients who were extubated within 8 hrs and beyond 8 to 24 hrs were 6.12 hrs and 12.88 hrs, respectively. We found that 185 patients (94.3%) were extubated within 24 hrs.

The overall duration of mechanical ventilation in our study was compatible to that reported in other studies.[2,5-7] On the other hand, the incidence of prolonged mechanical ventilation for more than 24 hrs was similar to that of the STS database (5.7% vs. 5.5%, respectively) and other studies.[8,9]

Prolonged or unnecessary delay in tracheal extubation results in increased complication rates for patients receiving mechanical ventilation, including pneumonia, airway trauma, death, and increased hospital stay.[17]

After successful extubation, none of the patients was reintubated, which shows that the time for extubation was precisely selected. Premature extubation in itself carries risks to the patients including difficulty in reestablishing an artificial airway, compromised gas exchange, an eight-fold higher ratio of nosocomial pneumonia, and 6 to 12-fold increased mortality risk.[10]

We found the most common cause of delayed extubation to be physician trend.

These patients had achieved criteria for extubation earlier, but just for more safety, they were extubated later during 8 to 24 hrs, except for 2 patients who were extubated at 24 to 48 hrs. Whether these patients would have had a problem in early extubation or not could not be determined. We, therefore, recommend that we change our strategies in these patients.

The second cause of delayed extubation was excessive postoperative bleeding. Eight of 26 bleeding patients required re-exploration in

the operation room for persistent mediastinal bleeding (4.08%).

This incidence is slightly high compared to that reported in other studies (4.8% vs. 1-3%). It seems that precise surgical hemostasis, stopping of all anticoagulant and antiplatelet agents prior to operation, proper heparin reversal, proper use of antifibrinolytics, considering off-pump coronary bypass, and correction of any coagulopathy upon occurrence will help prevent excessive post-operative bleeding.[11]

Bleeding may delay extubation due to hemodynamic instability, pulmonary edema (cardiogenic or non-cardiogenic), and re-exploration.

In our study, the incidence of cardiovascular instability was high (SBP>180 mmHg, SBP<90mmHg, significant arrhythmias). Hypotension and hypertension commonly occur with any type of cardiac surgery and are multi-factorial.

Vasodilation associated with hyperdynamic circulatory state can occur after cardiac surgery and presents with systemic hypotension in association with an increased cardiac output.[3]

Myocardial function is temporarily depressed from the period of ischemia and reperfusion. Hypothermia and elevated levels of catecholamines lead to an increase in systemic vascular resistance and systemic hypertension, which increase afterload and depress myocardial performance.[12]

Our objective was to maintain a stable BP (systolic BP 100-130mmHg). Use of appropriate fluids, inotropes, and/or vasodilatory agents was our strategy for management. After the reduction of inotropic agents to low levels, the patients were extubated during different intervals.

The patients with metabolic acidosis were treated by the reversal of the causes (hypovolemia, oliguria, anemia, hypothermia …). Following the correction of acidosis, all of them were extubated within 24 hrs.

Patients with poor FVC level (n=9) could be secondary to respiratory muscle weakness for reasons including diaphragmatic paralysis or prolonged effects of neuromuscular blockade. We did not subdivide these categories further. All of these patients were extubated within 24 hrs. We recommend using newer anesthetic agents that are compatible with ultra-fast-track extubation.

The possible reasons for hypoxemia in these patients include acute lung injury, microatelectasis, or increased ventilation/ perfusion mismatch due to postoperative use of vasodilators.[13-15] These have transient deleterious effects on pulmonary function.[3] In our study, the patients were able to overcome these effects within 24 hrs and were extubated without significant respiratory problems. Three patients had hypoxemia due to focal findings on chest radiography.

After 48 hrs, it is difficult to differentiate complications secondary to surgery and those due to the need for long-term mechanical ventilation such as ARDS. Finally, a proportion of patients with failure to extubation due to various reasons will vary from institution to institution, based on differences in patient populations and management strategies.

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