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Research Article

Adaptive Support Ventilation Versus Synchronized Intermittent Mandatory Ventilation for Fast track Extubation after Cardiac Surgery

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Received: August 13, 2019; **Published:** September 20, 2019

Abstract

Introduction: Adaptive support ventilation (ASV) is a controlled mode in artificial ventilation which could be transformed to an intelligence partial mechanical ventilation support in weaning phase; dependent on operator arrangement. ASV could maintain predefined minute ventilation with a good respiratory configuration by adjusting positive inspiratory pressure and respiratory pattern base on the patient's lung compliance and metabolic necessity.

Synchronized intermittent mandatory ventilation (SIMV) is an appropriate mode for mechanical ventilation support which, the ventilator attempts to deliver the mandatory breaths in synchrony with the patient's inspiratory efforts. The aim of this study was to compare ASV mode and SIMV mode into fast-track respiratory weaning protocols after uncomplicated coronary artery bypass graft.

Material and Method: A group of patients (80 patients) was enrolled in a cross sectional case-control multi centric study. Patients divided in two groups. After cardiac surgery under general anesthesia, patients were randomly assigned in two groups ASV and SIMV (40 patients in each group). Both them have their own weaning protocol and post cardiac surgery period for fast-track; were divided into two predefined phases. First phase was considered; primary mechanical ventilation set up (stabilizing patients in post operation period) and second phase was weaning approach, when spontaneous breathing occurred and completing weaning process by tracheal extubation.

Results: Eighty patients enrolled in our study. Thirty eight patients completed the ASV mode weaning protocol, and 36 patients completed the standard SIMV mode weaning protocol. 2 patients in group ASV and 4 patients in group control were excluded by explicit, predefined criteria due to complications. We could not attribute complications to our ventilation strategies. The primary outcome of the study was duration of tracheal intubation (artificial ventilation time before extubation) that; it was shorter in ASV group than SIMV group ($P < 0.03$). A large difference was seen between two groups in total sedation doses ($P < 0.03$), arterial blood gas parameters ($P < 0.04$), hemodynamic parameters and need for inotropic medications.

Conclusion: ASV protocol makes shorter duration of tracheal intubation and simplifies Ventilator management in fast-track patients after coronary artery bypass graft surgery. In evaluation of potential advantages of ASV on recovery time; we supposed that Mechanical Ventilation support after cardiac surgery could set up base on ASV.

Keywords: *Synchronized Intermittent Mandatory Ventilation; Adaptive Support Ventilation; Weaning; Cardiac Surgery*

Introduction

Fast-track extubation in cardiac surgery was defined as rapid tracheal extubation during 6 hours after operation. It has been established as an option in post cardiac surgery care [1,2]. Studies demonstrated that Fast-track cardiac surgery programs in elective cardiac surgery patients, including coronary artery bypass graft patients does not increase perioperative morbidity and mortality [3] thus; it considered safe in uncomplicated patients but needs advanced protocols and closed control. It has resulted in reductions in intensive care unit and hospital length of stay, resource utilization, and cost without any effects on patients outcome [2-5].

Different method have been suggested to reduce the mechanical ventilation time in post cardiac surgery period, including short-duration anesthetic medications, normo-thermic operation, heart beating surgery (off pump), reduction of cardiopulmonary bypass time [4,6].

Time between patient entrance to intensive care unit (ICU) and extubation is a golden time for re-evaluation. It considered for adequacy of re-warming, hemodynamic stability, controlling hemodynamic problems by medication, postoperative hemostasis and arterial blood gas parameter compensation. Exclusive mechanical ventilation protocol aimed to accelerating respiratory weaning process after cardiac surgery [2,4,6,7].

Different modes of mechanical ventilation have different effects on patient hemodynamic, respiratory variables and patient out com especially after cardiac surgery. The synchronized intermittent mandatory ventilation (SIMV) is one of the most common ventilator mode used in post cardiac surgery period. SIMV mode allows the patient to have spontaneous breathing along with mandatory breathes by machine in a coordinated process. SIMV is typically used for the weaning process from ventilators, but like many other ventilation modes it has its own shortcomings in which the increasing of the patients' effort of breathing is noticeable [4,7].

Adaptive support ventilation (ASV) is an intelligence mode of ventilation that guaranty preset patient minute ventilation base on body weight, sex and age independent of the patient's activity. Inspiratory pressure and ventilator rate are adjusted during a minute according to patient metabolic need and lung compliance to maintain an optimal respiratory configuration. ASV mode has been used for weaning process in different patients successfully [2,4,8].

We propose that use of ASV mode could accelerate respiratory weaning process (fast-track extubation) after cardiac surgery so; a cross sectional case-control randomized multi center study was set up to determine whether a weaning protocol based on ASV mode resulted in a reduction in time of extubation in comparison with SIMV mode.

Materials and Methods

The study was conducted between June 2018 and March 2019 in the open heart ICU of two hospitals (Jamaran Hospital and Amir-almomenin Hospital) and all patients scheduled for elective coronary artery bypass grafting under cardiopulmonary bypass. Written informed consent was obtained from the patients before cardiac surgery. Our preoperative exclusion criteria were poor myocardial function (preoperative ejection fraction lower than 30% by echocardiography), recent myocardial infarction, chronic obstructive pulmonary disease, drug abuse, disturb liver function test, renal failure or serum creatinine level more than 2 mg/dl, history of seizure, history of cerebro-vascular stroke and, sever coexisting disease (diabetes mellitus or systemic hypertension).

Patients in Amir-almomenin Hospital considered as control group and respiratory weaning was done with standard protocol base on SIMV mode and patients in Jamaran Hospital entered in ASV based weaning protocol. Method of weaning process, Fast-track Extubation, mechanical ventilation protocols were defined for each hospital separately.

The postoperative exclusion criteria determined as; any conditions hindering the fast-track approach including, postoperative hemorrhage, repeat operation, postoperative myocardial ischemia, refractory hypoxemia, neurologic complications.

After relatively similar anesthesia induction and maintenance; Cardiopulmonary bypass was performed under moderate hypothermia (32 - 35°C), using a membrane oxygenator and ruler pump.

All patients were transferred to the open heart ICU with tracheal intubation, where they were managed according to a preset protocol, including fluid resuscitation, blood transfusion, Dopamine or Epinephrine, and/or nitroglycerin infusion to keep mean arterial pressure about 70 mmHg. Patient control analgesia base on standard protocol was prescribed for all patients.

A strategy was designed for weaning process after cardiac operation base on ASV and SIMV.

The ventilator used during the study was Hamilton Raphael- C2, software version 2.2x.

Post cardiac surgery period for fast-track; were divided into two predefined phases. First phase was considered; initially mechanical ventilation set up (stabilizing patients in post operation period) and second phase was weaning approach, when spontaneous breathing occurred and completing weaning process by tracheal extubation.

In ASV group; the primary settings of the ventilator consist of three parameters including; ideal body weight, the percentage of the minute ventilation desired and the maximal inspiratory pressure. The ventilator determines the patient's respiratory compliance and resistances during an initial test of five breaths and delivers pressure-controlled ventilation, while optimizing inspiratory pressure and respiratory rate. The latter determines the respiratory rate associated with the least work of breathing as a function of the expiratory time constant. As soon as the patient performs an inspiratory effort, which is detected for every breath, the percentage of the minute ventilation support decrease ten percent every 15 minutes, up to total support 30 percent. The level of support is continuously adapted to the patient's respiratory rate and tidal volume to achieve the desired minute ventilation using a favorable breathing pattern. The initial ventilator settings in ASV group were minute ventilation (MV) at 100% of the estimated MV, oxygen inspiratory fraction of 60%, positive end-expiratory pressure (PEEP) of 5 cmH_2O, peak airway pressure (PIP) of 22 cm H_2O and flow trigger sensitivity of 2 l/min.

Arterial gas analysis (ABG) performed every hour up to extubation and each modification of the ventilator settings was tested after 15 minutes by ABG analysis. Our arterial carbon dioxide and oxygen pressure ($PaCO_2$, PaO_2) target defined 35 - 45 and more than 75 mmHg, respectively.

Phase 1 lasted until patients breathed spontaneously greater than 15 minutes then; respiratory weaning protocol could progress after ABG parameters were checked and clinical criteria of patient intolerance were resolved (inotropic medication dose less than 0.05 mcg/kg/m for Epinephrine and less than 5 mcg/kg/m for Dopamine; meanwhile mean blood pressure is more than 70 mmHg).

Standard group was ventilated initially by SIMV mode, MV 8 ml/kg with a decelerated flow waveform, respiratory rate of 12 breaths/min, pressure support 14 mmHg while; oxygen inspiratory fraction, PEEP and flow trigger were look like ASV group.

Demographic data of patient, weight, height and body mass index collected in a check list. Our primary outcome was the duration of respiratory weaning time while other variable like hemodynamic parameter (heart rate and invasive arterial Pressure), ABG parameters, total dose of inotropic agents, patients body temperature, duration of surgery and bypass time, total dose of sedative-hypnotic medications) were written and record. Data inter into computer and analyzed by appropriate test by SPSS version 19 and P-value less than 0.05 was considered statistically significant.

Results

Eighty patients enrolled in our study (Table 1). Thirty eight patients completed the ASV mode weaning protocol, and 36 patients completed the standard SIMV mode weaning protocol. Six patients were withdrawn from the study. Two patients in group ASV and 4 patients in control group were excluded according to explicit, predefined criteria due to complications.

Characteristic	ASV	SIMV	P-Value
Number of patients	32	36	
Age(yr)	58 ± 5	56 ± 6	0.8
Sex(m/f)	20/18	19/17	0.8
Height	168 ± 8	170 ± 9	0.7
Body mass index (BMI) kg/m^2	26.4 ± 3.5	26.6 ± 3.2	0.8
Cardio pulmonary bypass duration	75 ± 18	82 ± 25	0.6
Ejection fraction pre bypass	50 ± 12	52 ± 10	0.7
Ejection fraction post bypass	55 ± 8	50 ± 12	0.5

Table 1: *Patients' criteria and surgery specifications.*

One patient in SIMV group was suffered from myocardial ischemia. 2 patients in SIMV group have abnormal post operation bleeding and one of them met re-operation. One patient in ASV group and one patient in SIMV group were excluded for cerebro-vascular accident. One patient in ASV group presented hypoxemia (due to transfusion related acute lung injury). We could not attribute complications to our ventilation strategies.

The duration of mechanical ventilation was shorter in group ASV (210 ± 40 min) than in group control (255 ± 45 minutes) and the duration of tracheal intubation was significantly, shorter in ASV group than SIMV group (P-value < 0.03).

A significant difference was seen between two groups in total sedation doses, control group need more sedative hypnotic agents (10 ± 2 mg midazolam and 200 ± 75 mcg Fentanyl versus 5 ± 2 mg midazolam and 125 ± 50 mcg Fentanyl) (P-value < 0.03).

There were more ABG analysis performed in group control and arterial blood gas parameters was better in ASV group in comparison with control group (P < 0.04).

Hemodynamic parameter in ASV group was more stable so the need to inotropic agents was significantly lower in ASV group (Epinephrine 0.08 ± 0.02 versus 0.10 ± 0.05, P-value: 0.03; Dopamine 4 ± 2 versus 6 ± 3, P-value: 0.04).

Discussion

In this cross-sectional case- control study we evaluated the effect of weaning strategy (ASV versus SIMV) on fast-track extubation in uncomplicated coronary artery bypass graft patients. Our major finding show that ASV protocol is acceptable method for fast track extubation in addition; patients in ASV group was extubated earlier without any problem or complication [17-19].

There are studies have evaluated the efficacy of weaning strategy and ventilator mode on fast-track extubation after cardiac surgery [1-4,9,10].

Akhtar MI and colleague conduct a cross sectional descriptive study on 290 patients under cardiac surgery by on pump method whom extubated with fast-track strategy. Their results showed Overall success in fast-track strategy was 51.9% and the peri-operative renal insufficiency, cross clamp time and intensive care unit stay were significantly lower in success group. They demonstrated fast-track respiratory weaning could be safe if there was a standard accepted protocol in contributed physician and nursing staff [11].

A study on ultra fast track anesthesia technique demonstrates adequate hemodynamic control in the patient if a fully integrated post-cardiac surgery unit was available [12].

Cassina and colleague in a Prospective observational study on 155 consecutive patients after fast-track cardiac surgery find out ASV mode is safe and easy to apply. ASV could apply for rapid extubation in suitable patients. They concluded ASV may facilitate postoperative respiratory management [13]. In contrast; a research study in 2009 emphasized on weaning automation with ASV is feasible and safe in non-fast-track coronary artery bypass grafting patients [14].

Aghadavoudi and colleague believe that ASV could facilitate postoperative respiratory management in fast-track cardiac anesthesia besides both ASV and SIMV have similar effect on respiratory weaning in the cardiac ICU. They suggested additional studies with structured protocol and proper use of neuromuscular monitoring devices in the ICU to evaluate weaning strategies with ASV [15].

A randomized controlled trial that compared the ventilation duration between ASV mode and pressure assist-control ventilation was showed; ASV could shorten the duration of weaning process from artificial ventilation with a fewer number of manual ventilator settings [16]. In our study; there were more ABG analyses performed in group control because control group need more manipulation for ABG parameter compensation and ABG parameter in ASV group was in better condition.

A significant different was seen between two groups in total sedation doses in our study, control group need more sedative hypnotic agents maybe due to prolong weaning process and tracheal intubation. Our finding was conforming to others.

Hemodynamic parameter in ASV group was more stable and it was parallel to similar study [20-22].

The need to inotropic agents was significantly lower in ASV group because of stable hemodynamic parameter in comparison to SIMV group. We find similar finding in other literature [20,23,24].

Conclusion

Recent advances in anesthetic techniques and new concepts about respiratory management have facilitated early extubation following cardiac surgery [3,4,23]. This present study demonstrate that a weaning protocol based on ASV mode of mechanical ventilation is applicable and ASV mode could potentially accelerate tracheal extubation in patients who experience a fast-track protocol after uncomplicated coronary artery bypass graft by on pump method while, need for sedation during weaning process is significantly low and patient have more cardiac and hemodynamic stability.

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Volume 8 Issue 10 October 2019