Original Article

Comparing the effects of adaptive support ventilation and synchronized intermittent mandatory ventilation on intubation duration and hospital stay after coronary artery bypass graft surgery

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Abstract

Background: Different modes of mechanical ventilation are used for respiratory support after coronary artery bypass graft (CABG). This study aimed to compare the effect(s) of using adaptive support ventilation (ASV) and synchronized intermittent mandatory ventilation (SIMV) on the length of mechanical ventilation (intubation duration) and hospital stay after coronary artery bypass graft surgery.

Materials and Methods: In a randomized control trial, 64 patients were ventilated with ASV as the experiment group or with SIMV as the control group after CABG surgery in Chamran Hospital of Isfahan University of Medical Sciences. The time of tracheal intubation and the length of hospital stay were compared between the two groups. Data were analyzed and described using statistical analysis (independent *t*-test).

Results: The mean time of intubation duration was significantly lower in ASV group compared with SIMV group. (4.83 h vs 6.71 h, $P < 0.001$). The lengths of hospital stay in the ASV and the SIMV groups were 140.6 h and 145.1 h, respectively. This difference was significant between the two groups ($P = 0.006$).

Conclusions: According to the results of this study, using ASV mode for mechanical ventilation after CABG led to a decrease in intubation duration and also hospital stay in comparison with the SIMV group. It is recommended to use ASV mode on ventilators for respiratory support of patients undergoing coronary artery bypass graft surgery.

Key words: Adaptive support ventilation, cardiac surgery intensive care unit, coronary artery bypass, coronary artery bypass graft surgery, intensive care unit, Iran, mechanical ventilation, nurses, nursing, synchronized intermittent mandatory ventilation

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Introduction

Patients are transferred to the heart surgery intensive care unit (ICU) to receive mechanical ventilation (MV) after coronary artery bypass graft (CABG) surgery.[1] Most problems associated with open heart surgery are related to the endotracheal tube and MV, including ventilator-associated pneumonia (VAP), barotrauma, cardiovascular disorders, tracheal damage, reduction in

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mucus discharge followed by the likelihood of lung collapse, inability in making communication, and anxiety.[2] The results of previous researches indicate the fact that as the duration of MV gets longer, more side effects will emerge.[3] Most studies conclude that it is safe to immediately remove endotracheal tube for most patients undergoing heart surgery.[4] The immediate removal of tracheal tube leads to a decrease in stay duration at ICU and hospital which consequently brings about reduction in expenses for patients and therapeutic centers.[5]

One of the most common respiratory modes used for patients receiving CABG is Synchronized Intermittent Mandatory Ventilation (SIMV).[6] Despite being useful, this respiratory mode has some known defects; in case the number of respirations from ventilator is decreased during weaning patients from the machine, they will face with reduction in ventilation, carbon dioxide retention, and respiratory acidosis.[7] Therefore, ICU nurses ought to provide continuous and precise caring during ventilation.[5] Another important problem is the need for conducting blood tests and frequent analysis of arterial blood gases (ABG) after any kind of reduction in the number of mechanical respirations.[2] Such a gradual and lengthy reduction in mechanical respirations leads to unjustified lengthening of weaning patients from ventilation machine.[8] As a result, it is of paramount importance to use a respiratory mode for giving ventilation to the patient which requires less engagement from ICU nurses and can smartly screen the patient's condition.[9] One of the modes that are administered in modern mechanical ventilators is Adaptive Supportive Ventilation (ASV).[10] This mode smartly monitors patients in each respiratory cycle.[11] In the absence of spontaneous respirations, the ventilator exerts controlled pressure ventilation on the patient, while it acts automatically and smartly as a supportive pressure mode by supporting the patient's respiratory attempts whenever s/he has spontaneous respiration.[12] Thus, no interference would occur between patient's respiratory attempts and the respiratory supports of the ventilator.[13]

In this regard, a study was carried out by Gruber *et al.* on patients receiving CABG.[9] The results indicated that there was a significant difference regarding improved hemodynamic parameters among patients who had received respiratory support through ASV mode compared with the SIMV group.

In another study by Dongelmans *et al*. on patients undergoing heart surgery,[14] the results revealed that ASV causes sooner spontaneous breathing in patients compared with SIMV and that the mechanical ventilator had changed from controlled to supportive mode in a shorter time.

In another study by Sulzer *et al*. on patients hospitalized at ICU after CABG,[15] it was found that using ASV mode leads to the shortening of the time needed for starting patient's spontaneous respirations compared with the SIMV mode and it also reduces the duration of MV in patients after heart surgery.

No noticeable researches have been done so far in our country (Iran) and even worldwide about using this respiratory mode and its usefulness for patients after CABG.[16] Furthermore, in spite of already mentioned advantages of this ventilation mode, especially for patients after CABG, this ventilation mode is not being commonly used in our country and also in the cardiac surgical centers in Isfahan, and the SIMV mode is still being used as a preferred, routine mode in the absence of evidence-based studies, and also, the ASV is used in some cases subjectively. Therefore, we decided to investigate the effects of using the ASV mode on the duration of MV and length of hospital stay among patients receiving CABG, in comparison with the SIMV mode.

Materials and Methods

In a two-group, one-stage clinical trial study, 64 patients were selected from among the patients receiving CABG who referred to Shahid Chamran Hospital affiliated with Isfahan University of Medical Sciences in 2014. They were selected through convenient sampling method with the aim of identifying the effect of using ASV mode on the duration of MV and the length of stay in hospital, and also, comparing it with the SIMV mode.

The research subjects aged minimally 25 and maximally 65, had an ejection fraction of more than 30% in their left ventricle, did not have any history of lung diseases like asthma or chronic obstructive pulmonary disease (COPD), had not undergone cardiopulmonary surgery, seizure, or brain stroke, and did not have any liver-related problems or liver disorders. In addition, they were stable hemodynamically at the time of being admitted into the ICU [mean arterial pressure (MAP) > 70 mmHg, heart rate (HR) <150, respiratory rate (RR) <40] and were not under the support of intra-aortic balloon pump. Accordingly, patients were excluded in case they experienced homodynamic instability during the study and were in need of receiving inotropic medications in dosages higher than usual (dopamine >20 mg/h, norepinephrine >0.5 mg/h, dobutamine >25 mg/h, and epinephrine in any dosage) or needed intra-aortic balloon pump.[11]

Excessive hemorrhage after surgery (discharges of chest tube more than 500 cc/h, more than 350 cc/h within 2 h,

or more than 1000 cc in total) and the need for surgical operation and repeated anesthesia due to any reason, including excessive hemorrhage at the organ under surgery, led to the exclusion of subjects from the research.[17]

After obtaining all required permissions from the Ethics Committee of the university and extracting the background characteristics of patients according to their profile data, the patients who met the inclusion criteria and signed the written consent form were selected and admitted into the research.

The patients in this research were allocated to two groups with 32 subjects in each group through randomized allocation method. One group received MV through ASV mode accidentally, while another group received MV through SIMV mode. In order to homogenize all conditions in both groups, all patients were supported by Raphael Ventilator during the research.

The patients in both groups were controlled thoroughly regarding cardiac monitoring, arterial blood pressure monitoring through arterial line, and the percentage of arterial blood oxygen saturation. In order to maintain their MAP more than 70 mmHg, inotropic medications like dopamine and norepinephrine were infused according to the patient's condition and physician's advice. Blood was transfused for maintaining hemoglobin more than 9 g/dl in case of necessity. Assessment regarding the need for painkillers, tranquilizers, and pain controllers was conducted and morphine sulfate was injected up to 1–2 mg if necessary, and in case of having autonomic symptoms like an increase in HR and breathing, which emerged as a result of lack of control over pain (after examining and rejecting all other causes), morphine sulfate was infused for the patient at 1–2 mg dosage. If any shivering occurred, pethidine was used at 25 mg dosage. No respiratory muscle relaxant medicine was used.[9]

The initial settings for the ASV group were adjusted in terms of ideal body weight, target minute volume (TMV) based on a percentage resulting from 100 ml/kg/min, and maximum pressure (Pasv limit). At the onset of respiratory support, the percentage of TMV (respiratory support percentage) was 100%, the limit of maximum pressure was 25 cm H2O and, consequently, the limit of maximum pressure alarm was set at 35 cm H2O. The amount of FiO2 was 50%, and positive end expiratory pressure (PEEP) for 4 h was 10 cm H2O and it was set at 5 cm H2O until extubation.[18] The ventilator initially acted as pressure-controlled ventilation (PCV) mode and provided respiratory support. Its settings changed automatically according to any changes in patient's respiration and its algorithm changed from pressure-controlled to pressure-support mode whenever the patient indicated any respiratory attempt. Therefore, the number of breathings was at patient's control. In case of an increase in the number of shallow breathings, the amount of pressure support (PS) was increased automatically.

Thirty minutes after the initial settings, arterial blood sample was sent to the hospital lab for analyzing ABG and evaluating patient's respiratory condition.[19] Accordingly, if the amount of PCO2 was lower than 35 mmHg or more than 55 mmHg, the percentage of respiratory support decreased or increased by 20%, respectively. If the trend of patient's respiratory condition was appropriate and the number of spontaneous breathings increased, the amount of support from the machine was reduced to 75%. When this situation continued for 30 min, the amount of support was reduced to 35%. After conducting thorough assessments, the patient was extubated after 30 min if s/he tolerated the current conditions and there were no reasons for not removing the endotracheal tube. In order to extubate the patient and remove the endotracheal tube, the following conditions were to be met: The patient had to respond to the researcher's questions and cooperate with him, the analysis of blood gases had to be at normal range, the number of spontaneous breathings without the support from the machine had to be 10–20 per minute (Fcontrol = 0), the inspiratory pressure had to be at 5–10 cm H2O, the discharges of chest tube had to be less than 100 ml/h, and the amount of urinary output had to be minimally 0.5 ml/kg/h.[18] If the patient faced respiratory distress throughout any of the aforementioned stages, the amount of support from the machine was again reset to previous amounts and the required assessments were carried out.

In the SIMV group, the initial settings included: Tidal volume of 6–8 ml/kg, number of breathings up to 10–14 per minute, amount of FiO2 coming to 50%, PEEP equal to 5–10 cm H2O, and a sensitivity rate of 1–2 cm H2O. Like the ASV group, the arterial blood sample was sent to the lab 30 min after starting ventilation for analyzing ABG and the respiratory condition of the patient was assessed accordingly. In case of need to modify the condition of respiration, the number of breathings was decreased or increased.[20] Any kind of change in the settings of the ventilator was assessed by using the test of analyzing ABG (30 min after enacting change).[17] When the patient started to breathe spontaneously, the number of respirations from the machine was reduced 2 digits per hour and after each reduction in the mandatory respirations of the machine, the assessment of respiratory condition and the analysis of ABG were carried out. The respiration mode was changed to PS if the patient had 6 breaths per minute for half an hour and the amount of PS was set at 10 cm H2O. The mode of the machine was reset to controlled mode in case

of having long-term or frequent apneas. If the conditions of patient were satisfactory, the amount of PS was reduced to 5 cm H2O. When the respiration condition was suitable, the patient was set at spontaneous mode and if the spontaneous respirations of the patient did not have any problem and s/he was quite conscious and awake, s/he was extubated according to the aforementioned criteria for the ASV group.

After removing the trachea tube, the patient received respiratory support through non-invasive, low-flow methods (nasal cannula or simple face mask) and all the necessary caring was provided by nurses at ICU.

The criteria for delaying the process of removing the endotracheal tube were as follows:

- Patient's lack of cooperation with and response to the researcher, respiratory distress, and unstable hemodynamic condition
- 200 mmHg < systolic blood pressure (SBP) <90 mmHg, HR > 140, RR > 35/min, SpO2 < 90%, PCO2 > 50 mmHg
- Existence of uncontrolled arrhythmia
- Discharges from the chest tube more than 200 ml over the last hour
- Ratio of FiO2 > 50%, PaO2/FiO2 < 150, and PEEP > 5 cm H2O.

After successfully removing the endotracheal tube, the checklist data were filled in by the researcher for each patient.

In order to assess the two parameters of MAP and SpO2, the intended numerical values were recorded every hour by using the data from the cardiopulmonary monitoring system.

The patients were visited by the specialist on the first day after surgery and their transfer to surgery ward was decided upon according to their conditions. The time of specialist's visitation at ward for releasing the patient was recorded as a criterion for identifying the duration of patient's stay at the hospital.

All of the machines were calibrated again before and after each use. The obtained data were analyzed by the SPSS software, ver. 16, and independent *t*-test.

Ethical considerations

The Ethics Committee of Isfahan University of Medical Sciences approved the study. In this study, letter of introduction issued by Isfahan Nursing and Midwifery School was delivered to the authorities of research environment. Research goals were explained to the patients, nurses, and physicians of research environment.

Results

In the present study, 64 patients who were undergoing CABG surgery participated, including 28 females (43.8%) and 36 males (56.2%). The samples were allocated to two groups, 32 in each, by using random numbers table. Comparison of individual and surgery characteristics of the subjects in the two groups is presented in Table 1.

The average time of MV in the ASV group was 4.83 h, while it was 6.71 h in the SIMV group. A significant difference was revealed on using independent *t*-test ($P < 0.001$, t: 4.11). The average time of stay at hospital in the ASV group was 140.6 h and it was 145.1 h in the SIMV group. This value was significantly lower than the SIMV group according to independent *t*-test ($P = 0.006$, t: 2.82) [Table 2].

Discussion

The results of the present study indicated that using the ASV mode for MV of patients undergoing CABG surgery leads to reduction of length of MV and the duration of hospital stay for these patients.

The results of a research by Dongelmans *et al.* on 128 patients after CABG surgery[14] indicated that the ASV mode results in sooner spontaneous respiration in patients compared with the SIMV mode and the ventilator takes shorter to change from controlled mode to supportive mode. However, despite these advantages, no significant difference was observed between the two groups regarding the length of MV. The main reason behind such a lack of difference between the two groups regarding the length

Table 1: Patient and surgery characteristics

	ASV group	SIMV group
Number	32	32
Gender (Male/female), %	(53.2/46.8)	(34.4/65.6)
Age (years), mean (SD)	57.9 (5.6)	58.3 (5.66)
Weight (kg), mean (SD)	66.56 (9.91)	68.7 (8.42)
Height (cm), mean (SD)	164.4 (8.35)	165.9 (7.51)
Body mass index, mean (SD)	24.53 (2.4)	24.89 (2.01)
Ejection fraction (EF) %, mean (SD)	47.03 (5.93)	49.1 (5.18)
Pump time (min), mean (SD)	76.16 (5.25)	76.64 (6.72)

SD: Standard deviation, ASV: Adaptive support ventilation, SIMV: Synchronized intermittent mandatory ventilation

Table 2: Patient outcomes

	Mean (SD)	
	ASV group	SIMV group
Length of mechanical ventilation (h)	4.83 (0.64)	6.71 (2.49)
Length of hospital stay (h)	140.06 (6.5)	145.1 (6.1)

of MV in their research might have been the fact that the amount of TMV was not reduced after the onset of spontaneous respirations in patients and its amount was maintained at 100% rate of ventilation volume until extubation. In contrast, in the present study, the amount of support provided by the machine faced with a descending trend from 100% to 75% and then to 35%.

Cassina *et al.*[17] compared two respiratory modes of ASV and PCV on 155 patients after CABG surgery. To mechanically ventilate patients in their study, they used the Raphael ventilator made by Hamilton Company. The results indicated that 86% of patients in the ASV group undergoing open heart surgery had undergone immediate extubation (during the first 6 h). The results of their research approve the findings of the present study.

Sulzer *et al.*[15] examined the effects of using the ASV and SIMV modes on 36 patients receiving MV from Raphael-Hamilton ventilator after undergoing open heart surgery for valve replacements and grafting coronary arteries. The results of their study indicated the fact that the ASV mode leads to shortening the time required for starting spontaneous respiration in patients after open heart surgery. It seems that the reason for the shorter time of MV in the ASV group was the reduction of controlled ventilation, which is congruent with the present research.

In a study carried out by Petter *et al.*,[21] two respiratory modes of ASV and SIMV were compared on 34 patients undergoing CABG surgery (16 patients with SIMV mode and 18 patients with ASV mode by using Raphael ventilator). Results of their research showed that although there was a lesser need to intervention and change in the settings of the mechanical ventilator compared with the SIMV mode and also the amount of alarm of the ventilator was lower than the SIMV group, there was no significant difference regarding the length of intubation between the two groups. The difference in results obtained compared to the present study can be due to the fewer number of participants compared with the present research.

Conclusion

Generally speaking, it can be concluded that applying the ASV mode for the MV of patients undergoing CABG surgery leads to shortening of MV duration and hospital stay. Therefore, it is recommended to use this mode for the MV of these patients. It is also suggested to replicate this research with more subjects in all medical centers in the country.

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Conflicts of interest

There are no conflicts of interest.

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