Trauma Mon. 2017 September; 22(5):e37663. doi: 10.5812/traumamon.37663.
Published online 2016 November 9. Research Article

Effect of Adaptive Support Ventilation Weaning Mode in Conventional or Standard Methods on Respiratory and Hemodynamic Performance Indices: A Randomized Clinical Trial

Jamileh Mokhtari Nouri,[1] Bahram Sohrabi,[1] Seyed Tayeb Moradian,[1,*] and Seyyed Mohammad Saied Ghiasi[2]
[1]Nursing Faculty, Baqiyatallah University of Medical Sciences, Tehran, IR Iran
[2]Medical Faculty, Anesthetist, Baqiyatallah University of Medical Sciences, Tehran, Iran

[*]*Corresponding author*: Seyed Tayeb Moradian, Nursing Faculty, Baqiyatallah University of Medical Sciences, Tehran, IR Iran. E-mail: t.moradyan@yahoo.com

Received 2016 March 07; **Revised** 2016 September 24; **Accepted** 2016 October 17.

Abstract

Background: Adaptive support ventilation (ASV) is one of the advanced modes of ventilation. The available evidence regarding the process of tracheal extubation indicates that staff working in intensive care unit usually performs the weaning process according to their own experiences and conventional methods.
Objectives: This study aimed to assess the effect of weaning with adaptive support ventilation in two conventional or standard methods on respiratory and hemodynamic performance indices in patients undergoing coronary artery bypass graft (CABG) surgery.
Methods: In this clinical trial, 100 patients candidate for coronary artery bypass graft (CABG) surgery at Jamaran hospital were allocated to experimental and control groups in 2015. Each group had patients. The conventional method of ASV was used in the control group without any intervention, while the standard method of ASV was applied in the experimental group. The groups were compared in terms of arterial blood gases, vital signs, atelectasis, and duration of weaning process.
Results: There was no statistically significant difference between the experimental and control groups in terms of demographic variables and disease history. Also, duration of mechanical ventilation and weaning process, duration of the patient's trigger to the tracheal extubation as well as other respiratory performance indicators and vital signs were similar between the groups ($P > 0.05$).
Conclusions: The results of this study indicate that in stable patients who have no history of lung problems, there is no need to apply the difficult weaning protocol. These patients can be weaned without any complication.

Keywords: Coronary Artery Bypass Graft (CABG) Surgery, Adaptive Support Ventilation Mode, Respiratory and Hemodynamic Indicators

1. Background

Coronary artery bypass graft (CABG) surgery is common (1). About 427000 patients annually undergo CABG in the USA (2). Following CABG the patient is transferred to intensive care unit (ICU) usually under mechanical ventilation in the first hours after surgery. The method and the time of tracheal extubation are among the most important factors influencing pulmonary complications (3). Therefore, interventions concerning mechanical ventilation are very important to decrease pulmonary compilations. Benefits and outcomes of these interventions have been evaluated in several studies such as a study on the benefits of fast tracheal extubation of patients undergoing CABG weaning from the ventilator (4).

The weaning process in CABG Patients is very important. It has an important role in hemodynamic stability. Inappropriate tracheal extubation can lead to adverse complications and outcomes in patients increased morbidity and mortality (5). Unsuccessful weaning and need for re-intubation are reported in some studies. Probable risks of re-intubation in cardiovascular patients highlights the necessity of conducting more studies in this regard (6, 7).

Tracheal Extubation in the first six hours after surgery can decrease pulmonary complications and improve patient's cardiac outcomes (8). This process is called fast track extubation (FTE) and is one of the accepted concepts in open heart surgery. FTE leads to a faster recovery and can decrease the length of the patient's ICU and hospital stay (4-9). FTE can decrease health care costs after cardiac surgery up to 50%. Accompanied by proper anesthesia technique during surgery and post-surgery management, FTE can be performed in patients undergoing CABG surgery without any specific complication (9).

Many studies have been conducted to evaluate the relationship between modes of ventilation and FTE. ASV is one of the advanced ventilation modes; it includes the benefits of the conventional ventilation modes; but excludes some complications. There are many studies in recent years regarding the efficacy of this mode of ventilation in different settings. Some studies have mentioned the usefulness of this mode compared to the conventional modes in patients undergoing CABG. ASV is a mode of ventilation that provides minimum minute ventilation. This mode includes a microprocessor controlled system that automatically leads the patient from controlled-mode ventilation to assist and then spontaneous ventilation in a completely adaptive form; ASV sets the ventilator according to the lung mechanic and respiratory effort of patient (10, 11). This mode, based on the clinical status of the patient, provides a range of ventilation support including pressure controlled ventilation (PCV), synchronized intermittent mandatory ventilation (SIMV), or pressure support ventilation (PSV) (10). In this mode, the ventilator frequently monitors respiratory system mechanics and changes its settings accordingly (12, 13). Among the benefits of using this mode, it can be pointed out to automatic adjustment of ventilator settings, automatic synchronization of ventilator based on the changes in lung mechanic, less need to manipulate the ventilator by the operator, improving coordination of the patient with the ventilator, and automatic reduction of the ventilator support (10, 11). The impact of ASV on the process of tracheal extubation and FTE in cardiac patients has been assessed recently. Despite the fact that ASV reduces mechanical ventilation time, there are still some problems (13). The process of weaning with ASV requires specific criteria (Figure 1). Tracheal extubation is usually conducted based on clinical judgment. ICU staff perform this process based on their experiences and the non-specific conventional routines of the ward (14).

Totally, in the process of tracheal extubation, there is high emphasis on tracheal extubation parameters and their role in successful tracheal extubation. The studies indicate professionals have little knowledge in this regard (15).

The study of Jung (1979) (16) regarding weaning criteria in patients ventilated with SIMV indicated that weaning parameters in patients who need short-term mechanical ventilation leads to success in weaning, but weaning standard parameters are less applied in patients who need long-term mechanical ventilation.

Despite the emphasis on the use of the protocol, some studies have not reported any benefit of the use of protocols during the weaning process (14).

2. Objectives

The current study was carried out to evaluate the effect of weaning with adaptive support ventilation in two conventional or standard method on respiratory and hemodynamic performance indices in CABG patients.

3. Methods

In this clinical trial, which was conducted in 2015, 100 patients undergoing CABG at Jamaran heart hospital were allocated to the intervention and control groups, each consisting of 50 patients. The patients were allocated to group A and group B through a lottery in which, the patients taking sheet A were allocated to the experimental group and those taking sheet B allocated to the control group. The patients were not aware of their group.

The inclusion criteria for this study were as follows: not suffering from severe respiratory disease (COPD, atelectasis, pneumonia), aged 30 - 70 years, and not having emergency or redo surgery. Patients who were hemodynamically unstable and needed high dose inotropes (more than 5 micrograms/kg/min dopamine or equivalent dose of other inotropes), and those bleeding more than 300 mL per hour and undergoing reoperation for bleeding were excluded from the study.

Considering $\alpha = 0.05$ and test power of 90% according to a previous study using the Altman Nomogram, the required sample size for this study was calculated for each group; by considering 10% of sample loss, finally there were 50 people for each group (11). One patient from the intervention group due to hemodynamic instability and one patient from the control group due to reoperation for bleeding control were excluded.

After transferring the patient to ICU, ASV was applied. Equal basic settings were employed on both groups and mechanical ventilation was performed by the researcher. The controlled settings of this mode included the following items: patient's ideal body weight (IBW), the value of minute respiratory volume in percentage (Min volume), positive end expiratory pressure (PEEP), fraction of inspired oxygen (Fio_2), the level of ventilator sensitivity for the breath of the patient (Trigger) and the maximum pressure that must be applied (cmH2o) (10, 13).

Then, weaning with mechanical ventilation was performed in the experimental group (Figure 1) and conventional method in the control group. The comparative impact of these two methods on patients' respiratory and hemodynamic indicators was assessed. Respiratory and hemodynamic indicators were measured and recorded during the weaning process. Accordingly, ABG, Spo2, systolic and diastolic blood pressure, arterial mean blood pressure, the amount of bleeding from the patient's chest tubes, the number of heart rate, breathing, central venus pressure (CVP) ,and temperature (T) were assessed and recorded before weaning and 1, 6, 12, and 24 hours after patients' extubation. Also, to assess atelectasis, daily chest X-ray was used for three days. All chest X-ray results were analyzed by an anesthesiologist who was blind to the group allocation. The study protocol was approved by the ethics committee and written informed consent was taken from all the participants.

Data were expressed by descriptive statistics (frequency, average) and analyzed by inferential tests such as chi-square, Mann-Whitney, and independent-t test.

4. Results

The mean age was 60.45 and 57.94 in the intervention and control groups, respectively (P = 0.14). In terms of gender, 12 participants (23%) in the intervention group and 18 (35%) in the control group were female (P = 0.15). other demographic variables are presented in Table 1. There was no statistically significant difference in demographic characteristics between the experimental and control groups (Table 1). The mean PaO_2 during the weaning was 109.85 in the experimental and 113.67 in the control groups. Also, there was no statistically significant difference between groups in the mean PaO_2 in pre extubation, and 6, 12, and 24 hours after extubation ($P > 0.05$). Our data shows that there was no significant difference in other hemodynamic and ABG indicators between the two experimental and control groups (Table 2). The incidence of atelectasis on the second postoperative day was 14 (26%) in the experimental group and 23 (45%) in the control group. This difference was statistically significant (P = 0.14). The incidence of atelectasis at other time intervals was not significantly different. The data are presented in Table 3. The time of mechanical ventilation was measured from ICU admission till the extubation. The mean mechanical ventilation time was 296 $\pm$ 96 and 276 $\pm$ 95 minutes in the experimental and control groups, respectively. There was no significant difference between the two groups in the weaning time (Table 4). In our study all of the patients were extubated easily and reintubation was not needed.

Table 1. Demographic Characteristics of the Participants in Two Groups

Variable	Experimental Group	Control Group	P Value
Age (mean), y	60.45	57.94	P = 0.14[a]
Gender No. (%)			
Female	12 (23)	18 (35)	P = 0.15[b]
Male	41 (77)	33 (65)	
EF (mean), %	49.62	48.82	P = 0.54[b]
Condition No. (%)			
Hypertension	36 (68)	32 (63)	P = 0.57[b]
Drug abuse	5 (9)	6 (12)	P = 0.69
Diabetes	23 (43)	21 (41)	P = 0.81[c]
Smoking	11(21)	8 (16)	P = 0.50[b]

[a]The results of the independent sample t-test.
[b]The results of the chi-square test.
[c]The results of the Fisher's Exact test.

5. Discussion

The results of the present study showed that there was no statistically significant difference between hemodynamic and respiratory performance indicators of patients undergoing ASV in conventional and standard methods. According to the results, in terms of arterial blood gases (ABG) analysis parameters, there is no significant difference between experimental and control groups in the amount of arterial oxygen saturation, and partial arterial pressure of oxygen and carbon dioxide.

In this regard, the results of the present study are consistent with the findings of the study of Soulerz et al. (2001) (17), while they are in contrast with those of the study of Grouber et al. (2008) (18). This contradiction may be attributed to the assessment of ASV and PRVC ventilation modes in the experimental and control groups in the study of Grouber.

However, there was a statistically significant difference between the two groups regarding the respiratory rate in the first 24 hours of weaning from mechanical ventilation. This issue can be considered a success in the stability of respiratory pattern after weaning. However, there was no significant difference between time intervals of assessment. In this regard, the results of this study are consistent with those of studies conducted by Soulerz et al. (2001), Chang et al. (1996), and Janson e al. (1997) (13, 17, 19). Also, Grouber et al. (2008) (18) reported the same results in terms of changes in blood pressure and heart rate, but not in terms of changes in respiratory rate. This difference can be due to the different methods of work; so that in the study of Grouber, ASV was compared to PRVC and volume support ventilation, while in the present study, ASV mode was assessed through standard and conventional approaches.

The mean duration of mechanical ventilation was lower in the control group; however, this difference was not statistically or clinically significant. Also, the duration of the first inspiratory effort after tracheal extubation (in

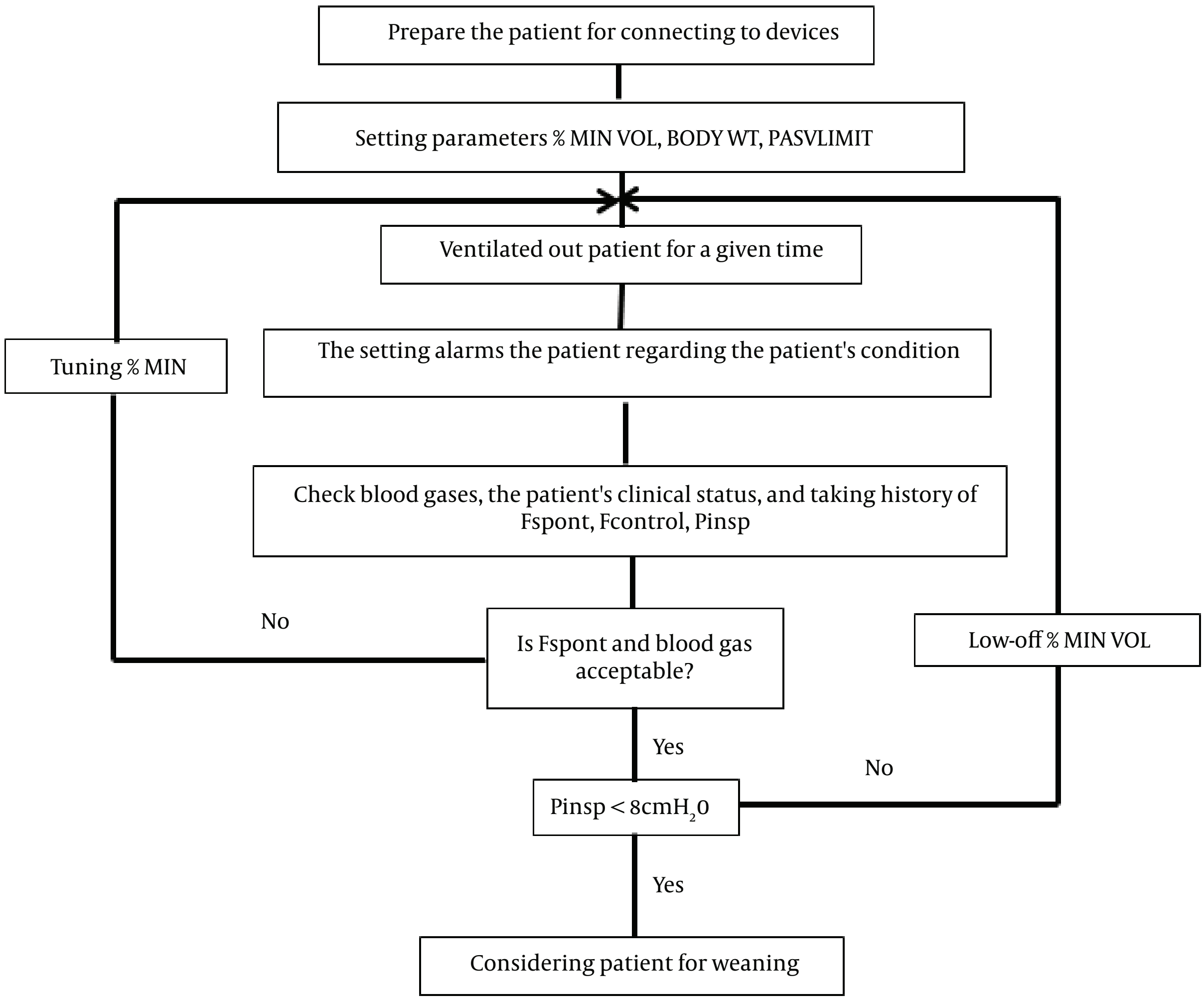

Figure 1. Standard Weaning Process Algorithm in ASV Mode

minute) was lower in control group, but this difference was not statistically or clinically significant. In this regard, this study is in agreement with the study of Petter et al. (2003) and the study of Dounglman et al. (2008) (11, 20). But, it is not consistent with the study of Sulerz et al. (2001) and Gruber et al. (2008) (17, 18). It seems that the reason for this similarity between the two groups in terms of duration of weaning process is the application of Fast Tracheal Extubation method in the two groups and also the use of similar medicines and methods in inducing and administering anesthesia during surgery.

In the present study, atelectasis was observed in more than 30% of the patients in the two groups. Other studies have revealed lower incidence rates, such as those performed by Stiller et al. (1994) (21) with an incidence rate of 7.1%, or Jenkins et al. with the rate of 10% (22). On the other hand, Brasher et al. (2003) (23) had a complication rate of 4.3% in the preoperative physiotherapy group compared to 2.6% in controls. Dull and Dull (1983) (24), recorded 77% of patients diagnosed with pulmonary complications following open-heart surgery and Westerdahl et al. (2001) (25) reported 67%. This incidence has been reported up to 100% in some studies (2). It seems that different reported values are due to different tools for measuring atelectasis and the extent to which the lung is involved as well as some clinical symptoms. Some studies have utilized CT scan and simple radiography as the tools of measurement and could report Micro atelectasis in some cases (2, 26). Different factors such as anesthesia and ventilation loss during surgery, increased extra vascular fluid, increased pulmonary capil-

Table 2. Hemodynamic Parameters of Participants in Two Groups[a]

Variable	Group	Pre-Weaning	Weaning	After 6 h	After 12 h	After 24 h
PaO_2, mmHg	experimental	121.7	109.85	97.87	86.81	79.58
	control	119.35	113.67	93.16	85.27	82.12
P value		0.82	0.49	0.32	0.72	0.56
$PaCO_2$, mmHg	experimental	35.23	38.11	36.4	35.77	35.21
	control	36.3	38.5	37.14	35.43	35.24
P value		0.45	0.68	0.37	0.65	0.97
SaO_2 %	experimental	97.21	97.06	96.47	95.49	94.25
	control	97.37	97.31	95.51	95	94.73
P value		0.73	0.56	0.09	0.43	0.49
MAP-mmHg	experimental	83.55	82.88	81.35	79.92	84.31
	control	83.05	83.09	79.23	80.27	81.73
P value		0.78	0.91	0.22	0.85	0.22
HR-No	experimental	90.38	94.09	86.38	83.53	84.26
	control	96.08	98.88	90.31	87.86	87.12
P value		0.08	0.12	0.12	0.12	0.23

[a]Values are expressed as mean.

Table 3. Atelectasis in the First to Third Days After Coronary Artery Bypass Graft Surgery in Two Groups[a]

Group	Experimental	Control	Chi-Square Test
Atelectasis			
First day			
Yes	10 (19)	11 (22)	$\chi^2 = 0.11$; df = 1; P = 0.73
No	43 (81)	40 (78)	
Total	53 (100)	51 (100)	
Second day			
Yes	14 (26)	23 (45)	$\chi^2 = 3.95$; df = 1; P = 0.04
No	39 (74)	28 (55)	
Total	53 (100)	51 (100)	
Third day			
Yes	15 (28)	21 (41)	$\chi^2 = 1.9$; df = 1; P = 0.16
No	38 (72)	30 (59)	
Total	53 (100)	51 (100)	

[a]Values are expressed as No. (%).

lary permeability, retention of fluid in the lungs base, diaphragm dysfunction, abdominal distention, atelectasis incidence after cardiac surgery, changes of chest wall due to incisions sternum, pleural effusion, and pain are stated as the causes of atelectasis (27, 28).

Table 4. Weaning Duration in Two Groups

Group Weaning Duration-Minutes	Mean (SD)	Independent t-Test
Experimental	296 (96)	T = 1.08; df = 102; P = 0.27
Control	276 (95)	

Data analysis using independent t test showed that there was no significant difference between the two groups in terms of atelectasis incidence in the first and third days after surgery; however, the incidence of atelectasis in the experimental group on the second day after surgery was lower than that of the control group. This finding is in line with those of obtained by Reyes et al. (1997) (29) and Chang et al. (1996) (30) although it was not consistent with the study results of Edmark et al. (2014) (31) and Johnson et al. (19).

In the present study, there was no difference between conventional and standard methods of weaning with ASV. Considering the lack of significant difference between the two methods, it seems that there is no need to perform difficult weaning protocols for the patients without underlying lung problems, not suffering from post-surgery complications, and undergoing mechanical ventilation just for a short time for recovery. Such protocols can increase the weaning time. This study does not recommend ignoring the routine weaning criteria. larger sample sizes and multicenter studies are needed.

Acknowledgments

This manuscript is extracted from an MA thesis registered at Baqiyatallah University of Medical Sciences with a registration code of IRCT2013033112878N1 at clinical trial center. Also, we thank Jamaran heart hospital staff for their assistance in this work.

Footnotes

Authors' Contribution: Bahram Sohrabi: literature review, data collection, and manuscript writing; Seyed Tayeb Moradian: data analysis. Jamileh Mokhtari Nouri, Ghiasi: Study design, data collection, and manuscript writing.

Funding/Support: The financial and material support of the research was provided by Baqiyatallah University of Medical Sciences.

References

1. Fergusson DA, Hebert PC, Mazer CD, Fremes S, MacAdams C, Murkin JM, et al. A comparison of aprotinin and lysine analogues in high-risk cardiac surgery. *N Engl J Med.* 2008;**358**(22):2319–31. doi: 10.1056/NEJMoa0802395. [PubMed: 18480196].
2. Westerdahl E, Lindmark B, Eriksson T, Friberg O, Hedenstierna G, Tenling A. Deep-breathing exercises reduce atelectasis and improve pulmonary function after coronary artery bypass surgery. *Chest.* 2005;**128**(5):3482–8. doi: 10.1378/chest.128.5.3482. [PubMed: 16304303].
3. Walsh TS, Dodds S, McArdle F. Evaluation of simple criteria to predict successful weaning from mechanical ventilation in intensive care patients. *Br J Anaesth.* 2004;**92**(6):793–9. doi: 10.1093/bja/aeh139. [PubMed: 15121724].
4. Amirghofran A, Rayatpisheh M. A comparative study of immediate and late extubation after open heart surgery. *Iran Cardiovas Res J.* 2007;**1**(1).
5. Wood G, MacLeod B, Moffatt S. Weaning from mechanical ventilation: physician-directed vs a respiratory-therapist-directed protocol. *Respir Care.* 1995;**40**(3):219–24. [PubMed: 10141679].
6. Rujirojindakul P, Geater AF, McNeil EB, Vasinanukorn P, Prathep S, Asim W, et al. Risk factors for reintubation in the post-anaesthetic care unit: a case-control study. *Br J Anaesth.* 2012;**109**(4):636–42. doi: 10.1093/bja/aes226. [PubMed: 22777658].
7. Yazdanian F, Azarfarin R, Aghdaii N, Faritous SZ, Motlagh SD, Panahipour A. Cardiac variables as main predictors of endotracheal reintubation rate after cardiac surgery. *J Tehran Heart Center.* 2013;**8**(1):42–7.
8. Savari S, Ebadi A. Fast extubation in heart surgery. *J Nur School, Baqiyatallah Uni Med Sci.* :52–7.
9. Akhtar MI, Hamid M. Success and failure of fast track extubation in cardiac surgery patients of tertiary care hospital: one year audit. *J Pak Med Assoc.* 2009;**59**(3):154–6. [PubMed: 19288941].
10. Fernandez J, Miguelena D, Mulett H, Godoy J, Martinon-Torres F. Adaptive support ventilation: State of the art review. *Indian J Crit Care Med.* 2013;**17**(1):16–22. doi: 10.4103/0972-5229.112149. [PubMed: 23833471].
11. Petter AH, Chiolero RL, Cassina T, Chassot PG, Muller XM, Revelly JP. Automatic "respirator/weaning" with adaptive support ventilation: the effect on duration of endotracheal intubation and patient management. *Anesth Analg.* 2003;**97**(6):1743–50. doi: 10.1213/01.ANE.0000086728.36285.BE. [PubMed: 14633553].
12. Brunner JX, Iotti GA. Adaptive Support Ventilation (ASV). *Minerva Anestesiol.* 2002;**68**(5):365–8. [PubMed: 12029247].
13. Chen SC, Cheng WE, Shih CM, Chu CC, Liu CJ. Adaptive support ventilation: Review of the literature and clinical applications. *Crit Care.* 2008;**19**(465-71).
14. Blackwood B, Burns KE, Cardwell CR, O'Halloran P. Protocolized versus non-protocolized weaning for reducing the duration of mechanical ventilation in critically ill adult patients. *Cochrane Database Syst Rev.* 2014(11):006904. doi: 10.1002/14651858.CD006904.pub3. [PubMed: 25375085].
15. Fiastro JF, Habib MP, Shon BY, Campbell SC. Comparison of standard weaning parameters and the mechanical work of breathing in mechanically ventilated patients. *Chest.* 1988;**94**(2):232–8. [PubMed: 3396396].
16. Jung RC. Weaning criteria for patients on mechanical respiratory assistance. *West J Med.* 1979;**131**(1):49. [PubMed: 483794].
17. Sulzer CF, Chiolero R, Chassot PG, Mueller XM, Revelly JP. Adaptive support ventilation for fast tracheal extubation after cardiac surgery: a randomized controlled study. *Anesthesiology.* 2001;**95**(6):1339–45. doi: 10.1097/00000542-200112000-00010. [PubMed: 11748389].
18. Gruber PC, Gomersall CD, Leung P, Joynt GM, Ng SK, Ho KM, et al. Randomized controlled trial comparing adaptive-support ventilation with pressure-regulated volume-controlled ventilation with automode in weaning patients after cardiac surgery. *Anesthesiology.* 2008;**109**(1):81–7. doi: 10.1097/ALN.0b013e31817881fc. [PubMed: 18580176].
19. Johnson D, Thomson D, Mycyk T, Burbridge B, Mayers I. Respiratory outcomes with early extubation after coronary artery bypass surgery. *J Cardiothorac Vasc Anesth.* 1997;**11**(4):474–80. doi: 10.1016/S1053-0770(97)90058-6. [PubMed: 9187998].
20. Dongelmans DA, Veelo DP, Bindels A, Binnekade JM, Koppenol K, Koopmans M, et al. Determinants of tidal volumes with adaptive support ventilation: a multicenter observational study. *Anesth Analg.* 2008;**107**(3):932–7. doi: 10.1213/ane.0b013e31817f1dcf. [PubMed: 18713908].
21. Stiller K, Montarello J, Wallace M, Daff M, Grant R, Jenkins S, et al. Efficacy of breathing and coughing exercises in the prevention of pulmonary complications after coronary artery surgery. *Chest.* 1994;**105**(3):741–7. doi: 10.1378/chest.105.3.741. [PubMed: 8131535].
22. Jenkins SC, Soutar SA, Loukota JM, Johnson LC, Moxham J. Physiotherapy after coronary artery surgery: are breathing exercises necessary? *Thorax.* 1989;**44**(8):634–9. doi: 10.1136/thx.44.8.634. [PubMed: 2799743].
23. Brasher PA, McClelland KH, Denehy L, Story I. Does removal of deep breathing exercises from a physiotherapy program including pre-operative education and early mobilisation after cardiac surgery alter patient outcomes? *Aust J Physiother.* 2003;**49**(3):165–73. [PubMed: 12952516].
24. Dull JL, Dull WL. Are maximal inspiratory breathing exercises or incentive spirometry better than early mobilization after cardiopulmonary bypass? *Phys Ther.* 1983;**63**(5):655–9. [PubMed: 6844410].
25. Westerdahl E, Lindmark B, Almgren SO, Tenling A. Chest physiotherapy after coronary artery bypass graft surgery–a comparison of three different deep breathing techniques. *J Rehabil Med.* 2001;**33**(2):79–84. doi: 10.1080/165019701750098920. [PubMed: 11474953].
26. Richter Larsen K, Ingwersen U, Thode S, Jakobsen S. Mask physiotherapy in patients after heart surgery: a controlled study. *Intensive Care Med.* 1995;**21**(6):469–74. doi: 10.1007/BF01706199. [PubMed: 7560489].
27. Kirkeby-Garstad I, Wisloff U, Skogvoll E, Stolen T, Tjonna AE, Stenseth R, et al. The marked reduction in mixed venous oxygen saturation during early mobilization after cardiac surgery: the effect of posture or exercise? *Anesth Analg.* 2006;**102**(6):1609–16. doi: 10.1213/01.ANE.0000219589.03633.BF. [PubMed: 16717296].

28. Needham DM, Korupolu R, Zanni JM, Pradhan P, Colantuoni E, Palmer JB, et al. Early physical medicine and rehabilitation for patients with acute respiratory failure: a quality improvement project. *Arch Phys Med Rehabil.* 2010;**91**(4):536–42. doi: 10.1016/j.apmr.2010.01.002. [PubMed: 20382284].
29. Reyes A, Vega G, Blancas R, Morato B, Moreno JL, Torrecilla C, et al. Early vs conventional extubation after cardiac surgery with cardiopulmonary bypass. *Chest.* 1997;**112**(1):193–201. doi: 10.1378/chest.112.1.193. [PubMed: 9228376].
30. Cheng DC, Karski J, Peniston C, Asokumar B, Raveendran G, Carroll J, et al. Morbidity outcome in early versus conventional tracheal extubation after coronary artery bypass grafting: a prospective randomized controlled trial. *J Thorac Cardiovasc Surg.* 1996;**112**(3):755–64. doi: 10.1016/S0022-5223(96)70062-4. [PubMed: 8800165].
31. Edmark L, Auner U, Hallen J, Lassinantti-Olowsson L, Hedenstierna G, Enlund M. A ventilation strategy during general anaesthesia to reduce postoperative atelectasis. *Ups J Med Sci.* 2014;**119**(3):242–50. doi: 10.3109/03009734.2014.909546. [PubMed: 24758245].