Original Article

A New Method for Extubation: Comparison between Conventional and New Methods

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Abstract

Background: *Extubation is associated with the risk of complications such as accumulated secretion above the endotracheal tube cuff, eventual atelectasia following a reduction in pulmonary volumes because of a lack of physiological positive end expiratory pressure, and intra-tracheal suction. In order to reduce these complications, and, based on basic physiological principles, a new practical extubation method is presented in this article.*

Methods: *The study was designed as a six-month prospective cross-sectional clinical trial. Two hundred fifty-seven patients undergoing coronary artery bypass grafting (CABG) were divided into two groups based on their scheduled surgery time. The first group underwent the conventional extubation method, while the other group was extubated according to a new described method. Arterial blood gas (ABG) analysis results before and after extubation were compared between the two groups to find the effect of the extubation method on the ABG parameters and the oxygenation profile.*

Results: *In all time intervals, the partial pressure of oxygen in arterial blood / fraction of inspired oxygen (PaO_2 / FiO_2) ratio in the new method group patients was improved compared to that in the conventional method; some differences, like PaO_2 / FiO_2 four hours after extubation, were statistically significant, however (p value = 0.0063).*

Conclusion: *The new extubation method improved some respiratory parameters and thus attenuated oxygenation complications and amplified oxygenation after extubation.*

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Introduction

For all the painstaking attention granted to tracheal intubation, especially with regard to the management of the difficult airway, precious little heed has thus far been paid to tracheal extubation.[1] Compared to 4.6% respiratory complications in the intubation of elective cases, extubation-related complications arise in 12% in the same group.[2] In some studies, researchers have tried to, along with other extubation criteria, indicate the application of oxy-

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hemoglobin as a guide to extubation decision.[3, 4]

During the extubation process, vital signs and oxy-hemoglobin saturation percentage should be monitored.[2, 5] Given that the period immediately after extubation is the most critical and vulnerable time for the patient, it is necessary for the medical staff to be alert and look for any sign or symptom of respiratory disturbance and hypoxia.[5]

The pulmonary effects of systemic inflammatory reaction after cardiac surgery are often modest and include decreased lung compliance, pulmonary edema, increased intrapulmonary shunt fraction, and decreased functional residual capacity and their resultant hypoxemia. Few patients (2%) undergoing cardiac surgery develop full-blown acute respiratory distress syndrome.[6] However, it is reported that up to 40% of cardiac surgery patients are readmitted to the intensive care unit (ICU) because of respiratory failure.[7, 8] During the last decade, many researchers have tried to address different strategies like the Open Lung Concept (OLC),[9, 10] Recruitment Maneuver,[11] and Positive End Expiratory Pressure (PEEP)[12, 13] as well as some other measures[14, 15] in order to attenuate hypoxemia after cardiac surgery.

Considering that there are no practical standards for extubation techniques and an increasing number of patients experience extubation-related complications,[16] we devised a novel extubation method and compared its results with those of the conventional method. The principal goals were: (1) to augment oxygenation by reducing the aspiration of the respiratory secretion and (2) to decrease intra-pulmonary shunting and its effects on the ICU stay.

Methods

The present study was a six-month prospective cross-sectional clinical trial. A pilot study was initially devised so as to determine the sample size, there being no similar study available in the existing literature. The results of the pilot study determined the number at 90 per study group with a confidence coefficient of 90%. Data were gathered by trained staff, matching was performed both for the patients and the methods, anesthesia techniques and drugs were coordinated and equalized by three experienced anesthesiologists, and randomization was done on a time basis: the new method was utilized in the first three months, followed by the conventional method in the ensuing three months.

The inclusion criterion was elective on-pump coronary artery bypass grafting surgery (CABG), and the exclusion criteria were comprised of severe lung disease, intubation before surgery, severe hemodynamic disturbance requiring balloon pumps, and need for operation before extubation. These data were comprised of the mean of Partial Pressure of Oxygen in Arterial Blood (PaO_2) = 87.7 mmHg with a standard deviation of 16.6 for the new method group and 95.31 mmHg with a standard deviation of 14.56 for the conventional method group.

Arterial blood gas (ABG) parameters constituted the main variables, particularly PaO_2 and PaO_2 / FiO_2 (Fraction of Inspired Oxygen), at one and four hours after extubation.

The time periods considered for the purposes of the present study were: 1) one hour after ICU admission; 2) just before extubation; 3) one hour after extubation; 4) four hours after extubation; 5) twelve hours after extubation; and 6) forty-eight hours after extubation.

The study population comprised post on-pump CABG patients who were under care in the ICU during a six-month period in 2008. Confounding factors were cardiopulmonary bypass (CPB) time, aortic cross-clamp time, body mass index (BMI), and underlying diseases such as chronic obstructive pulmonary disease, diabetes mellitus, smoking, reoperation, and dialysis.

The inclusion criteria were composed of CABG without any co-surgery, intubation in the operating room, and consent for participation in the study. The exclusion criteria were comprised of valvular disease requiring surgery, pneumonia, hemodynamic disturbance, intra-aortic balloon pump (because it induces inflammation), respiratory distress, urgent or elective intubation, carbon dioxide pressure (PCO_2) > 45mmHg, oxygen pressure (PO_2) < 60 mmHg, forced expiratory volume in one second (FEV_1) < 60% or FEV_1 / FVC (forced vital capacity) < 60% and vital capacity (VC) < 50%, ejection fraction (EF) < 30%, need for reoperation before extubation, neurological complications, consciousness disorder, significant neurological defect, and BMI > 40.

Immediately after ICU admission, the cuff pressure was controlled and was thereafter monitored every eight hours. Next, the ventilator machine was set on SIMV-PSV (SIMV: synchronized intermittent mechanical ventilation, PSV: pressure support ventilation): Vt (tidal volume) = 8 cc/kg of ideal body weight, frequency of intermittent mandatory ventilation (F) (IMV) = 10/min; F (IMV + PSV) = 15/min, I/E (inspiratory-expiratory time ratio) = 1/2, PEEP = 5 cmH_2O, PSV = 5 cmH_2O above total inspiratory pressure support, (PEEP) = 10 cmH_2O), pressure support = 10 cmH_2O, oxygen flow = 60 lit/min, and FiO_2 < 50%. Subsequently, FiO_2 was adjusted based on PaO_2.

The rapid shallow breathing index (RSBI), which is the proportion of respiratory rate/ tidal volume, was considered a criterion for extubation: if this proportion was > 105, the patient was regarded as not being able to stand extubation (Crawford J, Otero R, Donnino M, Garcia J, Khazal R, Lenoir T. Rapid shallow breathing index–a key predictor for noninvasive ventilation. Critical Care 2007;11:169). Before extubation, the Recruitment Maneuver was done for all the patients.

In the conventional extubation method, the patient's mouth was washed and suctioned using normal saline (10 cc). Next, separation from the machine was done. In aseptic condition,

the patient's tracheal tube was thereafter suctioned using a suction tube with a caliber ≤ 1/3 the caliber of the patient's tracheal tube. Then, the tracheal tube cuff was evacuated and patient was asked to take a deep breath. In the climax of the inspiration, the patient was extubated.

In the new method, the patient's mouth was suctioned dry (without liquid). Then, only if it was necessary, intra-tracheal suction was done. Afterward and before evacuating the tracheal tube cuff, the system's PEEP was set to 15 cmH_2O and PSV to 20 cmH_2O. Next, immediately after evacuating the cuff with a syringe, the patient's mouth and pharynx were suctioned cautiously. And finally, the tracheal tube was removed along its curve.

Extubation in both methods was done by trained nurses. If there was secretion in the pharynx, it was suctioned again and the patient was encouraged to cough or swallow the secretion and to breathe deeply. The patient was set in a semi-sitting posture (30-45 degrees) and oxygenation was done with nasal oxygen, and if necessary, by using a face mask with an oxygen reservoir bag.

Based on ethical rules, in the fifth and sixth time periods, ABG analysis (as an invasive procedure) was conducted in accordance with the rules of our ICU or the clinical judgment of the anesthesiologist.

The results are reported as mean ± standard deviation (SD) for the quantitative variables and are summarized by absolute frequencies and percentages for the categorical variables. Differences in the distribution of the characteristics in the patients were examined using the chi-square test for the discrete variables, while the t-test was employed to examine differences between the two groups for the continuous variables. Logistic regression analysis was utilized to eliminate the effect of the confounders. For the statistical analyses, the statistical software SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL) and the statistical package SAS version 9.1 for windows (SAS Institute Inc., Cary, NC, USA) were used.

Results

This study initially recruited 257 patients, and after 5 patients were eliminated because their intubation time exceeded 36 hours as a result of decreased consciousness level, hemodynamic instability, or the other underlying diseases, the study population was divided into the conventional group (n = 154) and the new method group (n = 98).Totally, 74.2% of the cases were male and 25.8% female:73.4% male and 26.6% female in the control group and 75.5% male and 24.5% female in the case group (p value = 0.7). According to the Chi-Square statistical method, there was no significant difference between the two groups. The distribution of the independent quantitative variables, in all the patients in the study and differentially in the two groups is shown in Table 1.

As regards the underlying diseases and risk factors, cigarette smoking was seen in 37.8% of all the patients, followed by diabetes mellitus (31.9%). There was no significant difference between the two groups in the percentage of the diabetic patients (p value = 0.98), chronic obstructive pulmonary disease (COPD) patients (p value = 0.08), cigarette smoking (p value = 0.84), and opium consumption (p value = 0.23). In terms of admission in the ICU (p value = 0.95), inotrope requirement (p value = 0.71) and balloon pump before extubation (p value = 0.71) and balloon pump two hours after ICU admission (p value = 1), there was no significant difference between the two groups. There was, however, a significant difference in the percentage of inotrope usage two hours after ICU admission: the control group 26% and the case group 12% (p value = 0.01). There was a significant difference between the two groups in the age average: 61.84 ± 8.86 years in the control group and 59.07 ± 10.05 years in case group (p value = 0.02), but the difference was not significant, clinically. There was no significant difference in the other variables like BMI (p value = 0.2), graft number (p value = 0.77), cardiopulmonary bypass (CPB) time (p value = 0.16), cross-clamp time (p value = 0.15), ejection fraction (EF) % (p value = 0.44), and FEV_1 / FVC (p value = 0.28) between the new method and control groups. Based on our findings, recorded in Table 2, some of the ABG parameters such as PaO_2, pH, and oxygen saturation (SpO_2) showed significant differences between the two groups, before extubation.

After extubation, all the patients were oxygenated by nasal cannulae unless there was 1) respiratory distress, 2) tachypnea > 35/min, or 3) PO_2 decrease < 60 mmHg, in which case, nasal cannulae were replaced with reservoir masks. The patients were, accordingly, assigned into two groups according to the usage of the nasal cannulae or reservoir mask: 9 (5.9%) patients in the control group and none of the patients in the case group required reservoir masks. (The assumption was that the reservoir mask provides 80% oxygenation and the nasal cannula 40 %.) One hour after extubation, the difference was significant (p value = 0.02). Four hours after extubation, 8 patients in the control group and none in the case group needed the reservoir mask and breathing via the nasal cannula was adequate to prepare desired oxygenation; nevertheless, the difference was not significant (p value = 0.08). With respect to inotrope or balloon pump requirement at one, four, and twelve hours after extubation, there were no significant differences between the patients of the conventional and new method groups. In the hours mentioned, p values were 0.8, 0.66, and 0.29, respectively, for inotrope demand and 0.59, 0.54, and 0.08 for balloon pump requirement. A comparison of the dependent variables between the two groups revealed no significant difference in the ICU length of stay (LOS) between the two groups (Table 3).

Table 1. Independent quantitative variables in the two groups of study*

	Total	Conventional Method	New Method	P value
Age (y)	60.8±9.4	61.8±8.9	59.1±10.1	0.02
Graft Number	3.4±0.8	3.4±0.9	3.4±0.8	0.77
CPB time (min)	68.0±23.9	69.5±25.8	64.5±18.1	0.16
Cross-clamp time (min)	41.3±14.8	42.2±15.5	38.7±12.5	0.15
BMI (Kg/m^2)	27.3±4.1	27.6±4.3	26.9±3.8	0.20
EF (%)	47.9±9.4	48.3±9.9	47.4±8.5	0.44
FEV_1/FVC	86.2±13.6	86.9±12.6	84.9±15.2	0.28

*Data are presented as mean±SD
CPB, Cardiopulmonary bypass; BMI, Body mass index; EF, Ejection fraction; FEV_1/FVC, Forced expiratory volume in 1 second/forced vital capacity

Table 2. Arterial blood gas parameters before extubation in the two groups of study*

	Conventional Method	New Method	P value
One hour after ICU Admission			
pH	7.4±0.1	7.4±0.1	0.89
PaO_2 (mmHg)	128.4±33.8	138.7±46.2	0.06
BE (mmol/L)	-4.9±3.2	-4.8 ± 2.9	0.76
SpO_2 (%)	97.9±1.5	98.0±1.4	0.74
Just before extubation			
pH	7.3±0.1	7.3±0.1	< 0.01
PaO_2 (mmHg)	110.8±25.0	119.3±28.9	< 0.01
BE (mm/L)	-4.8±2.9	-4.9±3.2	0.66
SpO_2 (%)	96.9±1.6	97.7±1.3	< 0.01

*Data are presented as mean±SD
pH, Hydrogen ion concentration; PaO_2, Alveolar oxygen partial pressure; BE, Base excess; SpO_2, Oxygen saturation

*Table 3. Length of stay in the ICU and arterial blood gas parameters after extubation in two groups of study

	Conventional Method	New Method	P value
LOS	40.6±31.4	42.7±30.5	0.61
One hour after extubation			
PaO_2 (mmHg)	96.4±23.7	100.3±22.4	0.21
SpO_2 (%)	96.2±1.9	96.6±1.9	0.06
pH	7.3±0.1	7.3±0.1	0.51
$PaCO_2$ (mmHg)	36.2±4.7	37.6±4.1	0.02
BE (mmol/L)	-4.5±2.8	-4.0±3.2	0.23
Four hours after extubation			
PaO_2 (mmHg)	94.5±24.7	96.1±18.8	0.64
SpO_2 (%)	96.1±1.9	96.7±1.5	0.03
pH	7.4±0.1	7.4±0.1	0.29
$PaCO_2$ (mmHg)	35.8±4.9	36.5±4.1	0.32
BE (mmol/L)	-3.7±2.7	-3.7±3.9	0.98

*Data are presented as mean±SD
ICU, Intensive care unit; LOS, Length of stay; PaO_2, Alveolar oxygen partial pressure; SpO_2, Oxygen saturation; pH, Hydrogen ion concentration; $PaCO_2$, Partial pressure of carbon dioxide in arterial blood; BE, Base excess

As it has been mentioned above, after weaning the patient from the respiratory machine, FiO_2 was estimated based on the patient's oxygenation way: 0.4 (40%) for the nasal cannula and 0.8 (80%) for the reservoir mask.

Among the independent variables, significant differences were seen in the variables of age (p value = 0.02), inotrope (p value = 0.01), and ABG factors (Table 2) like PaO_2 (p value = 0.02), pH (p value = 0.01), and SpO_2 (p value = 0.001) when using the "t-test". Nonetheless, PaO_2 / FiO_2 was not different between the two groups statistically. Ultimately, the "regression" statistical method was utilized to consider the confounding effect(s) of these factors.

Among the ABG factors, one hour after extubation, partial pressure of carbon dioxide in arterial blood ($PaCO_2$) in the control group was lower than that in the case group, significantly (Table 3). A comparison of $PaCO_2$, four hours after extubation, between the two groups demonstrated recovery in $PaCO_2$ reduction, with the difference not constituting a significant difference anymore. Four hours after extubation, SpO_2 exhibited improvement in the case group by comparison with that in the control group; their difference was statistically significant (p value = 0.03) (Table 3).

Finally, PaO_2 / FiO_2 = 225 (approximately the average level), at which the new extubation method had the most efficiency, was considered as the cut point. A comparison of this proportion between the two groups showed that PaO2 / FiO_2 < 225 (PaO_2 / FiO_2 less than 225) was about 51.3% and 37.3% in the conventional and new method groups, respectively, at one hour after extubation, and also, 54.2% and 32.7% in the control and case groups, respectively, at four hours after extubation; their differences were statistically significant. The other ABG variables such as pH, BE (base excess), and PaO_2 did not show significant statistical differences between the two study groups, although almost all of them exhibited improvement in the new method group. Furthermore, twelve hours after extubation, most of the patients who required ABG, and all of them, forty-eight hours after that, were in the control group. There was a higher rate of requirement to the reservoir mask than the nasal cannula in the control group than that in the case group at one hour after extubation, with the difference being significant. Also, at four hours after extubation, there was no requirement to the reservoir mask in the case group but 8 patients in the control group required the usage of the reservoir mask; as a result, breathing via the nasal cannula seemed appropriate for providing proper oxygenation in the case group. The percentages of the patients with Po_2 / Fio_2 < 200 (PaO_2 / FiO_2 less than 200) at one and four hours after extubation were smaller in the case group than in the control group, but their differences were not significant (Table 4).

At one hour after extubation, 7 (4.6%) patients in the control group showed PO_2 / FiO_2 < 150, whereas none of the patients in the case group developed this complication; their difference was significant. Also, in the control group, at four and twelve hours after extubation, 9 and 10 patients showed PO_2 / FiO_2 < 150 (PaO_2 / FiO_2 less than 150), respectively, while no patient experienced a similar situation in the new method group. At forty-eight hours after extubation, in the open method group, 8 patients (of 20), who required ABG, had respiratory parameters within the range of PO_2 / FiO_2 < 150. In contrast, no patient required ABG forty-eight hours after extubation in the other group (Table 5).

As is mentioned in the results, variables that might affect the findings were regarded as confounding variables. Considering the variables of age, gender, BMI, EF, intubation time, FEV_1 / FVC, and PaO_2 / FiO_2 in the "logistic regression" test demonstrated that the new method decreased the extubation complications in PaO_2 / FiO_2 < 225 at one and four hours after extubation, and PO_2 / FiO_2 < 200 at one, four, and twelve hours after extubation. However, only the difference in PaO_2 / FiO_2 < 225 at four hours after extubation was statistically significant between the two groups (Table 6).

Additionally, the multivariable linear regression test, SPSS 16, showed a higher range of PaO_2 / FiO_2 at one hour after extubation and PaO_2 / FiO_2 at four hours after extubation in the patients with the new extubation method than that in those with the conventional extubation method (8.888 mmHg and 8.248 mmHg, respectively); there were, however, no significant differences.

Table 4. Oxygenation in range of PaO_2 / FiO_2 < 200 in the two groups of study

	Conventional Method	New Method	P value
One hour after ICU admission	35 (23.0)	26 (29.5)	0.25
Just before extubation	29 (19.0)	14 (18.2)	0.80
One hour after extubation	45 (29.6)	15 (18.1)	0.05
Four hours after extubation	49 (34.5)	14 (26.9)	0.31
Twelve hours after extubation	58 (56.9)	8 (42.1)	0.23
Forty-eight hours after extubation	16 (80.0)	-	-

*Date are presented as n (%)

PaO_2/FiO_2, Alveolar oxygen partial pressure / fraction of inspired oxygen; ICU, Intensive care unit

Table 5. Oxygenation in range of PaO_2 / FiO_2 < 150 in the two groups of study

	Conventional Method	New Method	P value
One hour after ICU admission	9 (5.9)	3 (3.4)	0.39
Just before extubation	3 (2.0)	1 (1.3)	1،00
One hour after extubation	7 (4.6)	0 (0)	0.04
Four hours after extubation	9 (6.3)	0 (0)	0.06
Twelve hours after extubation	10 (9.8)	2 (10.5)	1.00
Forty-eight hours after extubation	8 (40)	-	-

*Date are presented as n (%)
PaO_2/FiO_2, Alveolar oxygen partial pressure / Fraction of inspired oxygen; ICU, Intensive care unit

Table 6. Results of multivariable linear regression tests

	OR	95% CI	P value
PaO_2/FiO_2 < 225			
One hour after extubation	0.62	0.30-1.29	0.20
Four hours after extubation	0.29	0.12-0.71	<0.01
PaO_2/FiO_2 < 200			
One hour after extubation	0.53	0.21-1.28	0.15
Four hours after extubation	0.63	0.25-1.57	0.32
Twelve hours after extubation	0.30	0.07-1.37	0.12

OR, Odds ratio; CI, Confidence interval; PaO_2/FiO_2, Partial pressure of oxygen in arterial blood / Fraction of inspired oxygen

Discussion

Tracheal extubation has captured precious little attention compared with intubation.[1] We sought to present the details of a new extubation method to prevent atelectasis and hypoxia and to augment PaO_2 / FiO_2 in the ICU for first time. Although we found no comprehensive report of a similar method to compare our results with, our new method and its goals, mechanically, bears considerable similarities with the open lung concept (OLC) recruitment maneuver and use of PEEP and continuous positive airway pressure (CPAP) during and after surgery. The application of the OLC results in fewer episodes of hypoxemia,[9, 10] and the use of PEEP as well as that of CPAP prevents the formation of atelectasis.[12, 13, 17] In all the above-mentioned methods, preventing atelectasis and its unavoidable profound and catastrophic consequences in highly inflame lung parenchyma after on-pump CABG are the main target. Our study would be deemed a new aspect of the OLC, which has been previously ignored. In comparison with the existing literature on the OLC, we placed greater emphasis on a very significant, albeit temporary, intervention which can significantly improve the patient's condition and could be considered a routine in other populations of ICU patients. Based on our results, even a short period of atelectasia plays an important role in the production of hypoxemia in latter phases; consequently, considering the OLC strategy, even at definite special times, can have a significant preventive effect for hypoxemia.

Among the ABG factors, one hour after extubation, $PaCO_2$ in the control group was significantly lower than that in the case group (Table 3). It is noteworthy that agitation, pain, and hypoxia can cause $PaCO_2$ reduction after extubation. Four hours after extubation, SpO_2 was better in the case group than in the control group, with the difference constituting statistical significance (p value = 0.03) (Table 3). Based on these differences and given the importance of oxygen saturation, the new extubation method seems more appropriate than the old one.

Finally, considering the cut point of 225 for PaO_2 / FiO_2, we found PaO_2 / FiO_2 < 225 in about 51.3% and 37.3% in the conventional and new method groups, respectively, at one hour after extubation and also 54.2% and 32.7% in the control and case groups, respectively, at four hours after extubation; the differences were statistically significant. Therefore, the efficiency of the new method for enhancing PaO_2 / FiO_2 and oxygenation rate was apparent in the level < 225. Regarding the other ABG variables such as pH, BE (base excess), and PaO_2, their differences were not significant statistically; be that as it may, almost all of them enjoyed improvement in the new method group. Furthermore, with respect to rough parameters, clinical need to perform ABG analysis, and use of reservoir masks or nasal cannulae, there were fewer patients with Po_2 / Fio_2 < 200 and PO_2 / FiO_2 < 300 at one and four hours after extubation in the case group. Although these differences are not statistically significant, they seem to further underscore the efficiency of the new method. At forty-eight hours after extubation, in the conventional method group, 8 patients (of 20), who required ABG, had respiratory parameters within the range of PO_2 / FiO_2 < 150, while none of the new method group patients needed ABG

forty-eight hours after extubation. Given the high rate of mortality and morbidity in such patients, these percentages should be regarded as a very important clinical parameter to compare the two groups and to introduce the new method as an effective and safe extubation method.

Considering confounding variables in the logistic regression test using SAS 9.1 software, we found that in almost all the time periods, PaO_2 / FiO_2 was higher in the new extubation method group; however, only PaO_2 / FiO_2 four hours after extubation < 225 between the two groups was statistically significant (Table 6).

These findings suggest that our new method of extubation enjoys an acceptable oxygenation profile after CABG by comparison with the conventional method.

One of the most important restrictions in this study was ethical limitations in redundant blood sampling for ABG. When the patients were discharged from the ICU, their catheters were off, usually. Therefore, afterward, blood sampling for ABG was limited for the patients who required it based on medical indications. In addition, after extubating and weaning the patients from the respiratory machine, FiO_2 was estimated based on the nasal mask or the reservoir mask, 40% or 80%, respectively.

We believe that accurate monitoring of all patients with PO_2 / FiO_2 < 200 and PO_2 / FiO_2 < 300, at least for forty-eight hours after extubation (when atelectasia, pneumonia, or the other extubation complications may have appeared), could indicate the differences between the two methods.

Conclusion

Considering all of the findings in the present study, we believe that our new extubation method could improve some respiratory parameters and thus lessen the complications and augment oxygenation after extubation. However, future studies are required to further confirm our results and improve our new extubation method.

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References

1. Miller KA, Harkin CP, Bailey PL. Postoperative tracheal extubation. Anesth Analg 1995;80:149-172.
2. Koga K, Asai T, Vaughan RS, Latto IP. Respiratory complications associated with tracheal extubation. Timing of tracheal extubation and use of the laryngeal mask during emergence from anaesthesia. Anaesthesia 1998;53:540-544.
3. Salam A, Smina M, Gada P, Tilluckdharry L, Upadya A, Amoateng-Adjepong Y, Manthous CA. The effect of arterial blood gas values on extubation decisions. Respir Care 2003;48:1033-1037.
4. Esteban A, Alía I, Gordo F, Fernández R, Solsona JF, Vallverdú I, Macías S, Allegue JM, Blanco J, Carriedo D, León M, de la Cal MA, Taboada F, Gonzalez de Velasco J, Palazón E, Carrizosa F, Tomás R, Suarez J, Goldwasser RS. Extubation outcome after spontaneous breathing trials with T-tube or pressure support ventilation. The Spanish Lung Failure Collaborative Group. Am J Respir Crit Care Med 1997;156:459-465.
5. Ead H. Post-anesthesia tracheal extubation. Dynamics 2004;15:20-25.
6. Ng CS, Wan S, Yim AP, Arifi AA. Pulmonary dysfunction after cardiac surgery. Chest 2002;121:1269-1277.
7. Kogan A, Cohen J, Raanani E, Sahar G, Orlov B, Singer P, Vidne BA. Readmission to the intensive care unit after «fast-track» cardiac surgery: risk factors and outcomes. Ann Thorac Surg 2003;76:503-507.
8. Bardell T, Legare JF, Buth KJ, Hirsch GM, Ali IS. ICU readmission after cardiac surgery. Eur J Cardiothorac Surg 2003;23:354-359.
9. Reis Miranda D, Struijs A, Koetsier P, van Thiel R, Schepp R, Hop W, Klein J, Lachmann B, Bogers AJ, Gommers D. Open lung ventilation improves functional residual capacity after extubation in cardiac surgery. Crit Care Med 2005;33:2253-2258.
10. Epstein SK. Endotracheal extubation. Respir Care Clin N Am 2000;6:321-360.
11. Celebi S, Köner O, Menda F, Omay O, Günay I, Suzer K, Cakar N. Pulmonary effects of noninvasive ventilation combined with the recruitment maneuver after cardiac surgery. Anesth Analg 2008;107:614-619.
12. Ishikawa S, Takahashi T, Ohtaki A, Sato Y, Suzuki M, Hasegawa Y, Ohki S, Mohara J, Oshima K, Morishita Y. Peripheral pulmonary atelectasis and oxygentation impairment following coronary artery bypass grafting. J Cardiovasc Surg (Torino) 2002;43:419-422.
13. Coussa M, Proietti S, Schnyder P, Frascarolo P, Suter M, Spahn DR, Magnusson L. Prevention of atelectasis formation during the induction of general anesthesia in morbidly obese patients. Anesth Analg 2004;98:1491-1495.
14. Lundstrøm LH, Nygård E, Hviid LB, Pedersen FM, Ravn J, Aldershvile J, Rosenberg J. The effect of thoracic epidural analgesia on the occurrence of late postoperative hypoxemia in patients undergoing elective coronary bypass surgery: a randomized controlled trial. Chest 2005;128:1564-1570.
15. Yahagi N, Kumon K, Haruna M, Watanabe Y, Matsui J, Hayashi H, Tanigami H, Takamoto S. Helium/oxygen breathing improves hypoxemia after cardiac surgery. Artif Organs 1997;21:24-27.
16. Mason P, Hardy D, Smith B. Extubation reflectivity. J Perioper Pract 2007;17:583-585.
17. Rusca M, Proietti S, Schnyder P, Frascarolo P, Hedenstierna G, Spahn DR, Magnusson L. Prevention of atelectasis formation during induction of general anesthesia. Anesth Analg 2003;97:1835-1839.