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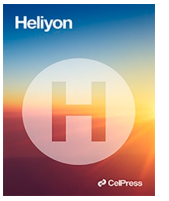

Research article

Effect of postoperative oxygen therapy regimen modification on oxygenation in patients with acute type A aortic dissection

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ABSTRACT

Objective: In this study, we investigated the effect of various oxygen therapy regimens on oxygenation in patients with acute type A aortic dissection (AAD).
Methods: A quasi-randomized controlled trial was conducted, in which patients with AAD hospitalized for surgery from June to September 2021 were assigned to the control group (patients received conventional oxygen therapy after postoperative mechanical ventilation, weaning, and extubation) and those who were admitted from October to December 2021 were assigned to the observation group [patients underwent optimally adjusted therapy based on the treatment of the control group, which mainly included prioritized elevation of positive end-expiratory pressure (PEEP) and restricted use of the fraction of inspired oxygen (FiO_2)].The postoperative oxygenation index, blood gas analysis, and duration of mechanical ventilation were compared between the two groups.
Results: There were significant differences in oxygenation observed at 2 h postoperatively between the groups. 12, 24, and 72 h postoperatively, the oxygenation index varied significantly between the two groups. There were statistically significant differences in the time effects of the oxygenation index and PaO_2 between the two groups, as well as significant differences in the length of stay in the intensive care unit.
Conclusion: For the postoperative care of patients with AAD, it is suggested that the minimum FiO_2 required for oxygenation of patients be maintained. In addition, it is possible to enhance PEEP as a priority when PaO_2 is low.

1. Introduction

Acute aortic dissection (AAD) is one of the most severe cardiovascular diseases, characterized by a fast onset of symptoms and extremely serious conditions [1,2].According to the Stanford classification, AAD affecting the ascending aorta is type A, which accounts for approximately 2/3rdof AAD and is susceptible to complicationssuch as dissection rupture, cardiac tamponade, shock, and circulatory failure. In most cases, surgery is necessary to prevent the devastating effects of AAD (hence referred to as acute type A aortic dissection) [3]. A high proportion of patients with AAD continue to have postoperative hypoxemia [4,5], which is mostly related to

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general anesthesia, local cooling, extracorporeal circulation, mechanical ventilation, and massive transfusion of blood. As high as 51.6% of patients with AAD have been documented to experience postoperative hypoxemia [6], the complication with the highest prevalence after cardiac surgery [7].

The management of mechanical ventilation is essential for preventing postoperative hypoxemia and improving the surgical efficacy [8]. Low tidal volume, airway plateau pressure restriction, positive end-expiratory pressure (PEEP) titration, and lung-protective ventilation with oxygen concentration restrictionare the current standards for mechanical ventilation [9,10]. There is no agreement regarding the setting and administration of the fraction of inspired oxygen (FiO_2) [11]. After cardiovascular surgery, the use of high FiO_2 is common in mechanically ventilated patients, but hyperoxemia can cause coronary artery spasm and cerebral vasoconstriction [12] and may lead to more severe pulmonary atelectasis and gas exchange impairment [13]. It is often assumed that critically ill patients can tolerate relatively low arterial partial pressure of oxygen (PaO_2) ("permissive hypoxemia") [14], although monitoring and study on this strategy have been limited due to safety concerns [15]. Therefore, it is necessary to verify in clinical practice whether postoperative oxygen treatment regimens can be modified to lower the incidence of postoperative hypoxemia and hyperoxemia in patients with AAD.

2. Materials and methods

1. General information

This study was approved by the Second Hospital of Shandong University's Ethics Review Committee (No. KYLL-2019[KJ]P-0200). The study participants consisted of patients with AAD admitted to the cardiovascular surgery department of the hospital between June and December 2021. A quasi-randomized controlled trial was conducted, with the control group consisting of patients with AAD hospitalized for surgery from June to September 2021 and the observation group consisting of those hospitalized from October to December 2021. Inclusion criteria for patients were as follows: (1) patients aged ≥18 years; (2) patients diagnosed with AAD by imaging and undergoing aortic replacement surgery with median sternotomy and cardiopulmonary bypass; (CPB). Exclusion criteria were summarized below: (1) patients who died intraoperatively; (2) patients who were pregnant; (3) patients with severe organic diseases of other organs, such as lung cancer; (4) patients with significant intermural hematoma of the aorta on intensive CT (Based on the surgeon's experience, patients with extensive intramural hematoma of the aorta are known to produce a large amount of inflammatory mediators in the body, which in turn increases the incidence of hypoxemia. Therefore, these patients are excluded from the study design.) (5) patients on long-term preoperative hormone therapy(Fig. 1).

2. Methods

All patients were subjected to combined intravenous and inhalation anesthesia, deep hypothermic circulatory arrest, bilateral antegrade cerebral perfusion, median sternotomy, and cardioplegia surgery (Ascending aorta replacement + total aortic arch

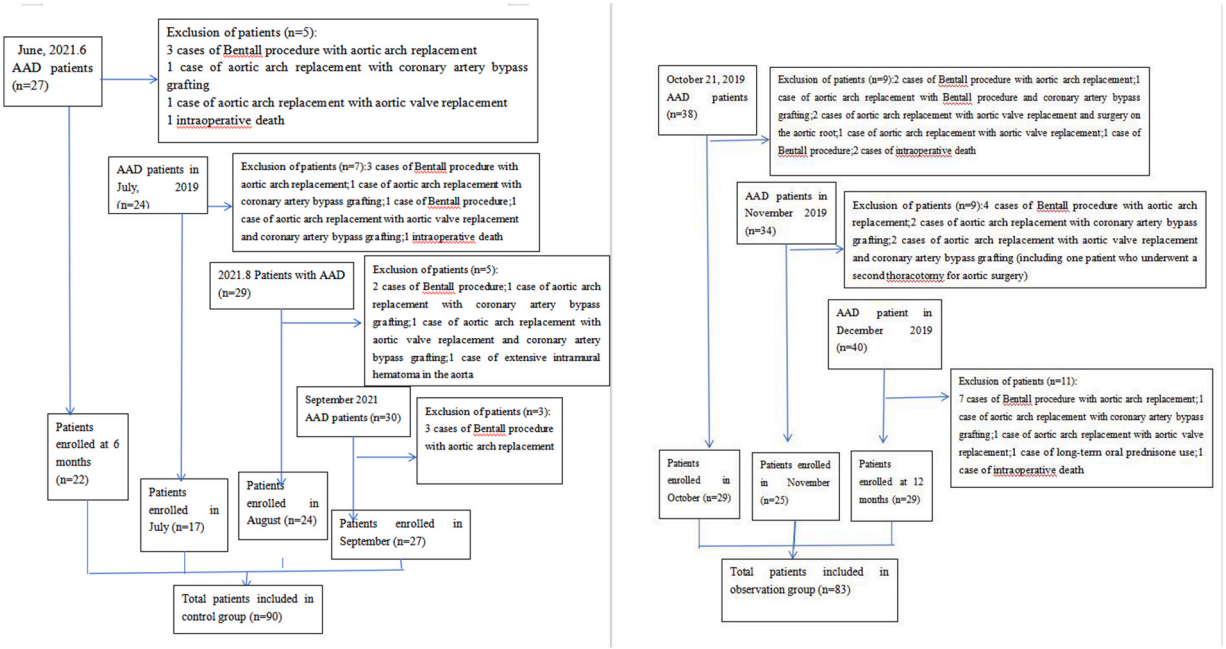

Fig. 1. Flowchart of patient enrollment.

replacement + stented elephant trunk procedure) under extracorporeal circulation.

The operative techniques were composed of cardiopulmonary bypass (CPB), moderate hypothermia (27–28 °C), circulatory arrest, andbilateral antegrade cerebral perfusion. Monitoring data included left radial anddorsalis pedis arterial pressures, main arterial pressure (MAP), central venous pressure (CVP), electrocardiography (ECG),pulse oxygen saturation (PaO_2), and arterial blood gas (ABG) analysis. Cerebralsaturation was monitored with near-infrared spectroscope (NIRS). After CPB was established, we cross-clamped the ascending aorta after the nasopharyngeal temperature dropped to 34 °C or lower. Consequently, cold blood cardioplegia was injected into the coronary Ostia antegrade or the coronary sinus retrograde directly to stop the heart. Then, a longitudinal incisionwas made on the ascending aorta.When the temperature reached 27–28 °C, all three branches of the aortic arch were separately clamped, and the systemic circulation stopped, furthermore,both the right axillary artery and left common carotid artery were used for cerebral protection.A stented elephant trunk was inserted into the proximal descending aorta and attached to the distal end of the graft. Subsequently, the systemic circu lation of the lower body was restarted through the right femoral artery.Afterwards, the left subclavian artery was initially anastomosed to the prosthetic graft, followed by the left common carotid artery, proximal aortic root, and innominate artery [16].To maintain surgical uniformity, excluding Bentall procedure with or without coronary artery bypass grafting (CABG).

The target temperature for controlled cardiac arrest during extracorporeal circulation is maintained at 27–28 °C, while the flow rate for bilateral cerebral perfusion stoppage is controlled at 10 ml/kg.

All intraoperative pulmonary ventilation was stopped at the time of circulatory arrest and resumed at the time of rewarming. Patients returned to the extracardiac intensive care unit (ICU) after the surgery and were orally intubated and linked to a invasive ventilator in synchronized intermittent mandatory ventilation mode, with a tidal volume of 6–8 mL/kg projected body weight and a respiratory rate of 14–20 breaths/min.Continuous bedside electrocardiography, invasive blood pressure monitoring, central venous pressure (CVP) monitoring, and oxygen saturation (SpO_2) monitoring were performed on all patients. The nature and dosage of vasoactive medications were modified based on monitoring of the circulatory system to maintain the stability of the circulatoryand internal environment.

Postoperatively, patients in the control group returned to the extracardiac ICU with 60–100% $FiO_2$and 0–5 mmHg PEEP, with PaO_2 maintained between 80 and 120 mmHg.After adjusting the ventilator parameters, blood gas analysis was conducted 0.5–1 h later. When PaO_2 was <80 mmHg, FiO_2 was increased by 10–20%, and if the target was not met, PEEP was increased to 5–8 mmHg. When PaO_2 was >120 mmHg, the FiO_2 was continually monitored or dropped by 10% per the doctor's instructions after consultation with the nurse. After weaning and extubation, PaO_2 was maintained at 80–120 mmHg by adjusting FiO_2 according to PaO_2.

Patients in the observation group received a postoperative $FiO_2$of 60%, which was increased to 65–80% in those with preoperative hypoxemia, and a PEEP of 3–8 mmHg, to maintain a PaO_2 of 80–100 mmHg.When PaO_2 was <80 mmHg, PEEP was first increased to 5–10 mmHg, up to 15 mmHg in the presence of a doctor, and if ineffective, FiO_2 was increased by 10–20%. FiO_2 was instantly decreased by 10–20% when PaO_2 was >100 mmHg. Blood gas analysis was performed 0.5 h after each modification of ventilator parameters until PaO_2 was maintained between 80 and 100 mmHg.After weaning and extubation, the FiO_2 was adjusted based on SpO_2 and PaO_2 to maintain SpO2 at 94%–100% and PaO_2 at 80–100 mmHg.

3. Observation indexes

(1) General information about patients

The ages, genders, diagnoses, BMIs, presence or absence of hypertension, coronary artery disease, diabetes, smoking history, and history of chronic obstructive pulmonary disease. and preoperative waiting time of the patients were compared.

(2) Intraoperative indexes

A comparison was made between the perioperative period blood transfusion volume, surgical time, extracorporeal circulation time, aortic cross-clamp time,and deep hypothermia circulation arrest time of patients.

(3) Postoperative indexes

Postoperative indexes included immediate blood pressure after patients were returned to the extracardiac ICU, mechanical ventilation parameters, airway pressure, CVP, heart rate, blood gas analysis and oxygenation index at postoperative 0 h, 2 h, 12 h, 24 h, and 72 h, incidence of hypoxemia and hyperoxemia within 72 h after surgery, postoperative mechanical ventilation time, and ICU length of stay.

Indications for extubation were as follows: (1) the PaO_2/FiO_2 ratio ≥150 mmHg or pulse oxygen saturation (PaO_2)> 90%; (2) FiO_2≤ 40%; (3) PEEP ≤5 cmH_2O; (4) PH > 7.25; (5) stable hemodynamic status (no or low dose of vasoactive drugs); (6) good recovery of muscle strength; (7) respiratory rate <30 breaths/min [8,17,18].

Indications for transfer out of ICU are listed below: (1) patients who were awake and cooperative; (2) spontaneous breathing rate <25 breaths/min without assisted mechanical ventilation; (3) PaO_2 80 mmHg and $PaCO_2$ 45 mmHg; (4) body temperature >36 °C; and (5) stable hemodynamics [19].

Hypoxemia was defined based on the following criteria: In this study, postoperative hypoxemia was defined as a PaO_2/FiO_2 ratio <200 mmHg within 72 h following surgery [20] and the absence of bilateral lung infiltrates on chest radiographs that could not be identified as acute respiratory distress syndrome [8]. PaO_2> 300 was considered as hyperoxia [21]. In our investigation, the

oxygenation index was the PaO_2/FiO_2 ratio.

4. Information collection

The intensive care information system (ICIS) variables electronic medical record system data were retrieved and entered into the electronic database. The ICIS variables with missing data were collected from the mobile nursing system. Before data analysis, the electronic database was refined by supplementing and verifying missing data against the original medical records.

3. Data analysis

Due to the limited number of patients in this study on the impact of post-CPB oxygen strategy on postoperative oxygenation in AAD patients, we have designed a single-center study. We initially determined that the research plan should reduce the incidence of hypoxemia by at least 20%, with a significance level of $\alpha = 0.05$ and power of $\beta = 0.20$, using the formula: $N = \frac{(Z_\alpha + Z_\beta)^2(1+1/k)p(1-p)}{(p_e - p_c)^2}$ $p = \frac{p_e + kp_c}{1+k}$ 计算 The required sample size is $n1 = n2 = 82.3 \approx 83$. Since AAD patients are in a state of mechanical ventilation after surgery, adjustments to mechanical ventilation settings are made during patient sedation, theoretically eliminating the possibility of loss to follow-up. Therefore, we will set $n1 = n2 = 83$ cases. As the control group data are historical controls, we extracted the number of patients from a full four months from June to September 2021, meeting the criteria with 90 cases. Finally, $n1 = 90$ cases and $n2 = 83$ cases were included.

Comparisons that included statistical descriptions and tests were made between control group and observation group. For the continuous variables, the normality was checked by the Shapiro-Wilk test, while the homogeneity of variance test was performed by Levene methods. Mean ± STD (Standard Deviation) and Median ± Qrange were stand for the average and degree of variation based on the data normality or not, respectively. For two different comparisons, the Pooled Equal Student's t-test were used based on data with the normality and homogeneity of variance, Satterthwaite unequalt's Test based on the data with the normality and without homogeneity of variance, Wilcoxon test based on the data without normality or/and without homogeneity of variance. MANOVA (Multivariate Analysis of Variance) was implemented for testing the difference, the trends over times of two groups and the interactions of two groups over times. Analysis of Variance (ANOVA) of Contrast Variables was indicated the test for each time points to first time point. For categorical variables, Pearson $\chi 2$ test or Fisher's exact test were performed to determine the association between/among groups. In addition, Spearman's rank or Pearson correlation tests were used for correlation analysis. All results of P-values <0.05 were considered statistical significant. All data were managed by Excel of Microsoft Office and analyzed using R 4.1.3 version.A statistically significant difference was determined to exist when $P < 0.05$.

4. Results

1. Comparisons of general information of patients in the two groups

There were 78 cases of coupled hypertension in the control group and 76 cases in the observation group, and there was no

Table 1
General information of patients in the two groups.

Items		Control group	Observation group	$\chi 2$ value	*P* value
Age (y, $\overline{X} \pm s$)		51.12 ± 14.29	51.99 ± 10.39	0.68	0.4949
Gender (%)	Male	63(36.42)	62(35.84)	0.59	0.4435
	Female	27(15.60)	21(12.14)		
Height (cm, $\overline{X} \pm s$)		171.70 ± 8.27	169.83 ± 7.98	1.92	0.0546
Weight (kg, $\overline{X} \pm s$)		79.32 ± 13.27	77.56 ± 14.45	0.84	0.4043
Body mass index (BMI, $\overline{X} \pm s$)		26.83 ± 3.59	26.86 ± 4.57	0.18	0.8601
Medical history[n(%)]					
Hypertension		61(67.78)	54(65.06)	0.19	0.6666
Coronary artery disease		10(11.11)	8(9.64)	0.04	0.8424
Diabetes		6(6.67)	3(3.61)	0.11	0.7392
Smoking		19(21.11)	10(12.05)	3.15	0.0760
Chronic obstructive pulmonary disease		13(14.44)	6(7.23)	2.383	0.0657
Preoperative waiting time (d, M (P25, P75)		0.46(0.35,0.75)	0.41(0.32,0.59)	1.22*	0.2219
Blood transfusion volume (1000 ml, M (P25, P75)		2.20 (1.74,2.66)	2.02 (1.49,2.62)	1.01*	0.3101
Surgical duration (min, $\overline{X} \pm s$)		453.76 ± 93.71	442.20 ± 72.61	0.26	0.7972
Extracorporeal circulation (min, $\overline{X} \pm s$)		156.24 ± 33.02	156.88 ± 42.99	104.11	0.1166
Aortic cross-clamp time (min, $\overline{X} \pm s$)		101.90 ± 28.08	97.51 ± 31.06	93.749	0.2196
Deep hypothermia circulation arrest time (min, $\overline{X} \pm s$)		25.76 ± 7.74	24.16 ± 4.56	26.128	0.3471
Mechanical ventilation time (h, M (P25, P75)		26.52(15.61,67.57)	25.32(15.28,47.13)	0.69*	0.4885
ICU stay (d, M (P25, P75)		7.00(5.21,10.01)	5.54(4.64,6.96)	3.34*	0.0008

Note: The chi-squared test was utilized as the test method. * represents the non-normally distributed data, which was evaluated using the Wilcoxon Z test.

statistically significant difference. Age, gender, body mass index, preoperative waiting time, intraoperative blood transfusion volume, and surgery duration did not change significantly between the two groups, indicating that the general data were comparable. Statistically, patients in the observation group had a considerably shorter ICU stay than those in the control group. In addition, the duration of mechanical ventilation was insignificantly shorter in the observation group than in the control group (Table 1).

2. Comparison of oxygen therapy parameters in postoperative mechanical ventilation between the two groups

The postoperative FiO_2 and first postoperative PEEP settings between the two groups were significantly different (Table 2).

3. Comparison of oxygenation between the two groups

The occurrence of hyperoxemia and hypoxemia was reduced in the observation group compared to the control group. Patients in both groups did not develop hyperoxemia 24 h and 72 h after surgery, and there was a significant difference in oxygenation at 72 h postoperatively. In the observation group, the incidence of hypoxemia decreased significantly (Table 3).

4. Repeated measures ANOVA of the oxygenation index in the two groups

At 12 h, 24 h, and 72 h following surgery, the oxygenation index of patients in the two groups differed significantly, and the differences in the time effects of the oxygenation index and PaO_2 were statistically significant (Table 4).

5. Two-way repeated measures ANOVA in the two groups

There were statistically significant differences in PH across different time points and between the two groups after 12 h postoperatively. In addition, PH values at 2 h, 12 h, 24 h, and 72 h postoperatively were statistically significantly different from the initial postoperative PH value (Table 5). There were statistically significant differences in the PaO_2/FiO_2 ratio between various time points and between the two groups at 12 h, 24 h, and 72 h postoperatively. In comparison to the initial postoperative PaO_2/FiO_2 ratio, the PaO_2/FiO_2 ratio was significantly different at 2 h and 12 h postoperatively, but not at 24 h and 72 h (Table 6). The differences in PaO_2 were statistically significant between different time points, but not between the two groups following surgery. In addition, there were significant variations between PaO_2 at 2 h, 24 h, and 72 h postoperatively and the initial postoperative PaO_2 (Table 7). There were statistically significant differences in $PaCO_2$ at various time points. $PaCO_2$ at postoperative time intervals was significantly different between the two groups, apart from the first postoperative $PaCO_2$. Moreover, compared to the first postoperative $PaCO_2$, $PaCO_2$ at 2 h, 12 h, 24 h, and 72 h postoperatively was significantly different (Table 8). Fig. 2 depicts the trends of each index within each group over time.

5. Discussion

In this study, we investigated the effect of various oxygen therapy regimens administered during postoperative mechanical ventilation based on arterial blood gases, on the prognosis of patients with AAD. After cardiovascular surgery, mechanical ventilation is largely utilized to guarantee adequate oxygenation and CO_2clearance and to prevent postoperative pulmonary complications, which were acquired under zero end-expiratory pressure (ZEEP) and high FiO_2 [9]. Extensive research has established the advantages of lung-protective ventilation during thoracoabdominal and cardiac operations [22]. During surgery, patients with AAD must receive blood products, as CPB induces systemic inflammation that may be suppressed by protective ventilation [23]. Protective ventilation includes not only a decrease in tidal volume, but also the modification of other crucial ventilation parameters, such as a larger PEEP, a faster respiratory rate, and a lower FiO_2 [9]. However, the precise configuration of PEEP and FiO_2 is still being explored.

Patients are at their most vulnerable during the period immediately following the start of artificial ventilation for cardiac surgery, and the ventilator settings must be optimized based on blood gas measurement. Underestimation of initial ventilator parameters can

Table 2
Comparison of oxygen therapy parameters during postoperative mechanical ventilation between the two groups.

Ventilation parameter	Control group	Observation group	χ2 value	*P* value
FiO_2 at postoperative 0 h ($\overline{X} \pm s$)	0.66 ± 0.10	0.62 ± 0.08	4.14	< 0.0001
FiO_2 at postoperative 2 h ($\overline{X} \pm s$)	0.67 ± 0.15	0.59 ± 0.12	3.67	0.0002
FiO_2 at postoperative 12 h ($\overline{X} \pm s$)	0.66 ± 0.10	0.61 ± 0.08	4.14	< 0.0001
FiO_2 at postoperative 24 h ($\overline{X} \pm s$)	0.66 ± 0.16	0.59 ± 0.12	3.67	0.0002
Tidal volume at postoperative 0 h (mL, $\overline{X} \pm s$)	527.11 ± 74.2	508.89 ± 69.25	0.04	0.9649
Tidal volume at postoperative 2 h (mL, $\overline{X} \pm s$)	514.16 ± 79.24	503.72 ± 75.33	0.88	0.3795
Respiratory rate at postoperative 0 h (breaths/min, $\overline{X} \pm s$)	16.02 ± 70.73	15.89 ± 0.58	0.73	0.4690
Respiratory rate at postoperative 2 h (breaths/min, $\overline{X} \pm s$)	15.8 ± 0.74	15.57 ± 1.37	1.35	0.1776
PEEP at postoperative 0 h (cmH_2O, $\overline{X} \pm s$)	3.58 ± 1.48	4.34 ± 1.21	3.51	0.0005
PEEP at postoperative 2 h (cmH_2O, $\overline{X} \pm s$)	5.65 ± 0.91	5.88 ± 1.49	0.10	0.9201

Table 3
Patient oxygenation in each group.

Time/groups	Control group			Observation group			Test method	P
	Hypoxemia	Normal oxygenation	Hyperoxemia	Hypoxemia	Normal oxygenation	Hyperoxemia		
Postoperative 0 h (n, %)	65(72.2)	23 (25.6)	2 (2.2)	55(66.3)	25 (30.1)	3 (3.6)	Fisher Exact	0.6491
Postoperative 2 h (n, %)	40(44.4)	46(51.5)	4 (4.4)	39(47.6)	42 (51.2)	1 (1.2)	Fisher Exact	0.5244
Postoperative 12 h (n, %)	51(57.3)	37 (41.6)	1 (1.1)	35 (42.7)	46 (56.1)	1 (1.2)	Fisher Exact	0.1045
Postoperative 24 h (n, %)	58(65.9)	30 (34.1)	0	44 (53.7)	38 (46.3)	0	Chi-square	0.1033
Postoperative 72 h (n, %)	60(69.8)	26 (30.2)	0	41 (50.6)	40 (49.4)	0	Chi-square	0.0114

Table 4
Description and statistic Test by Group at time points.

VarName	Time	stats	Control group	Observation group	Statistic	Statistic Value	P Value
pH	Time1 (0 h)	Mean ± STD	7.34 ± 0.09	7.32 ± 0.09	Pooled Equal Student's *t*-Test	0.91	0.3615
	Time 2 (2 h)	Median ± QRange	7.45 ± 0.09	7.47 ± 0.11	Wilcoxon Z	2.02	0.0431
	Time 3 (12 h)	Median ± QRange	7.47 ± 0.06	7.50 ± 0.08	Wilcoxon Z	2.69	0.0071
	Time 4 (24 h)	Median ± QRange	7.48 ± 0.07	7.49 ± 0.06	Wilcoxon Z	1.4	0.1629
	Time 5 (72 h)	Median ± QRange	7.47 ± 0.06	7.47 ± 0.06	Wilcoxon Z	0.27	0.7849
PaO2/FiO2 ratio	Time1 (0 h)	Median ± QRange	140.84 ± 131.96	153.33 ± 123.33	Wilcoxon Z	1.46	0.1451
	Time 2 (2 h)	Median ± QRange	217.57 ± 189.67	200.84 ± 175.00	Wilcoxon Z	0.06	0.9560
	Time 3 (12 h)	Median ± QRange	166.00 ± 177.75	226.31 ± 162.50	Wilcoxon Z	3.02	0.0025
	Time 4 (24 h)	Median ± QRange	153.50 ± 116.00	191.25 ± 115.00	Wilcoxon Z	2.96	0.0030
	Time 5 (72 h)	Median ± QRange	169.00 ± 87.05	192.50 ± 92.86	Wilcoxon Z	2.46	0.0137
PaO2	Time1 (0 h)	Median ± QRange	88.50 ± 79.00	94.00 ± 72.00	Wilcoxon Z	0.62	0.5343
	Time 2 (2 h)	Median ± QRange	136.50 ± 97.00	112.50 ± 86.00	Wilcoxon Z	1.55	0.1223
	Time 3 (12 h)	Median ± QRange	87.00 ± 66.00	102.00 ± 54.00	Wilcoxon Z	0.75	0.4552
	Time 4 (24 h)	Median ± QRange	80.00 ± 34.50	85.50 ± 35.00	Wilcoxon Z	1.09	0.2757
	Time 5 (72 h)	Median ± QRange	80.00 ± 26.00	84.00 ± 26.00	Wilcoxon Z	0.15	0.8791
PaCO2	Time1 (0 h)	Mean ± STD	43.74 ± 7.48	43.40 ± 7.13	TTest	0.31	0.7556
	Time 2 (2 h)	Median ± QRange	39.00 ± 9.00	35.00 ± 8.00	Wilcoxon Z	3.12	0.0018
	Time 3 (12 h)	Median ± QRange	39.00 ± 6.00	37.00 ± 7.00	Wilcoxon Z	3.25	0.0012
	Time 4 (24 h)	Mean ± STD	39.84 ± 4.34	38.43 ± 4.61	TTest	2.06	0.0410
	Time 5 (72 h)	Median ± QRange	40.50 ± 8.00	40.00 ± 6.00	Wilcoxon Z	1.84	0.0656

*The Pooled Equal Student's *t*-test is used for statistic test if the sample tested is Normal distribution with Homogeneity of Variance tested; the Satterthwaite Unequal t's *t*-test is used for normal distribution without Homogeneity of Variance Tested; the Wilcoxon Z is used for those sample that is not normal distribution and not Homogeneity of Variance Tested.

swiftly result in life-threatening acid-base imbalances [24], making the initiation of mechanical ventilation a double-edged sword for patients. In this study, we primarily investigated the initial parameter settings and optimal adjustment strategy of PEEP and FiO_2 for postoperative mechanical ventilation in patients with AAD. In our study, the FiO_2 was originally established at 60% in the observation group and raised by 5–20% in patients with preoperative hypoxemia, with a mean of 62%, which was significantly lower than the 66% FiO_2in the control group.The oxygen therapy was then modified appropriately depending on the arterial blood gases of the patients,

Table 5
Repeated measures analysis of variance (MANOVA test).

Variable Names			Statistic Test and P value	
			F	P
PH	Overall MANOVA Test	Group	0.41	0.5231
		Time (Wilks' Lambda)	77.51	<0.0001
		Group*Time (Wilks' Lambda)	1.95	0.1049
	Tests of Hypotheses for Between Subjects Effects	Group	0.41	0.5231
	Univariate Tests of Hypotheses for Within Subject Effects	Time	119.74	<0.0001
		Group*Time	2.33	0.0546
	Comparison of between Machine at each time point	Time1 (0 h)	1.65	0.2009
		Time 2 (2 h)	1.20	0.2752
		Time 3 (12 h)	5.79	0.0172
		Time 4 (24 h)	1.28	0.2591
		Time 5 (72 h)	0.98	0.3247
	Analysis of Variance of Contrast Variables			
	Time2 vs Time1	Mean Trend	171.75	<0.0001
		Group	3.68	0.0569
	Time3 vs Time1	Mean Trend	238.25	<0.0001
		Group	4.44	0.0366
	Time4 vs Time1	Mean Trend	293.42	<0.0001
		Group	2.30	0.1312
	Time5 vs Time1	Mean Trend	187.94	<0.0001
		Group	0.10	0.7509

Table 6
Repeated measures analysis of variance (MANOVA test).

Variable Names			Statistic Test and P value	
			F	P
PaO2/FiO2 ratio	Overall MANOVA Test	Group	3.71	0.0557
		Time (Wilks' Lambda)	13.85	<0.0001
		Group*Time (Wilks' Lambda)	0.92	0.4543
	Tests of Hypotheses for Between Subjects Effects	Group	3.71	0.0557
	Univariate Tests of Hypotheses for Within Subject Effects	Time	14.76	<0.0001
		Group*Time	1.57	0.1794
	Comparison of between Machine at each time point	Time1 (0 h)	0.62	0.4331
		Time 2 (2 h)	0.04	0.8342
		Time 3 (12 h)	5.40	0.0213
		Time 4 (24 h)	4.36	0.0383
		Time 5 (72 h)	3.91	0.0495
	Analysis of Variance of Contrast Variables			
	Time2 vs Time1	Mean Trend	36.88	<0.0001
		Group	0.26	0.6104
	Time3 vs Time1	Mean Trend	17.91	<0.0001
		Group	2.29	0.1324
	Time4 vs Time1	Mean Trend	1.42	0.2345
		Group	0.94	0.3326
	Time5 vs Time1	Mean Trend	0.45	0.5033
		Group	0.33	0.5669

with adjustments focused on the prioritization of PEEP elevation and the quick drop of FiO_2 based on the initial blood gas data.From Tables 3 and it can be observed that although there was an overall improvement in the observation group compared to the control group, the incidence of hypoxemia still remains relatively high. Apart from the factors related to AAD itself, the conservative design and adjustment of FiO_2 during the study implementation have limited the research results. It is necessary to increase the adjustment range appropriately in future work, while ensuring patient safety. Both the preset and subsequent adjustments of FiO_2 and PEEP should be intensified and varied, aiming for a more dynamic and individualized approach. This may lead to better outcomes in terms of protective lung ventilation for patients, reducing ischemia-reperfusion injury, and improving prognosis.The results revealed that the observation group had significantly shorter ICU stays.A study [25] has indicated that using higher FiO_2 levels after cardiac surgery may increase postoperative oxidative stress reactions in patients, leading to vasoconstriction, reduced organ perfusion, and myocardial damage. This can result in prolonged ICU stays for patients. On the other hand, strategies using lower FiO_2 levels have been shown to have beneficial effects on patients' respiratory and hemodynamic status, thereby reducing ICU stay time. After optimal adjustment of the mechanical ventilation regimen at postoperative 72 h, there was a significant difference in oxygenation between the two groups indicating that the incidence of hypoxemia was significantly reduced at postoperative 72 h after adjustment of the oxygen therapy regimen and that the use of higher PEEP effectively improved the oxygenation of patients and was effective in terms of lung protection. In addition, the PaO_2/FiO_2 ratio showed significant differences at three postoperative time points: 12 h, 24 h, and 72 h, indicating that

Table 7
Repeated measures analysis of variance (MANOVA test).

Variable Names			Statistic Test and P value	
			F	P
PaO2	Overall MANOVA Test	Group	0.36	0.5490
		Time (Wilks' Lambda)	32.79	<0.0001
		Group*Time (Wilks' Lambda)	0.76	0.5555
	Tests of Hypotheses for Between Subjects Effects	Group	0.36	0.5490
	Univariate Tests of Hypotheses for Within Subject Effects	Time	36.39	<0.0001
		Group*Time	1.00	0.4066
	Comparison of between Machine at each time point	Time1 (0 h)	0.05	0.8167
		Time 2 (2 h)	2.27	0.1340
		Time 3 (12 h)	0.04	0.8491
		Time 4 (24 h)	0.00	0.9612
		Time 5 (72 h)	0.58	0.4491
	Analysis of Variance of Contrast Variables			
	Time2 vs Time1	Mean Trend	18.81	<0.0001
		Group	2.47	0.1176
	Time3 vs Time1	Mean Trend	0.30	0.5853
		Group	0	0.9453
	Time4 vs Time1	Mean Trend	27.02	<0.0001
		Group	0.07	0.7936
	Time5 vs Time1	Mean Trend	27.62	<0.0001
		Group	0.26	0.6134

Table 8
Repeated measures analysis of variance (MANOVA test).

Variable Names			Statistic Test and P value	
			F	P
PaCO2	Overall MANOVA Test	Group	10.00	0.0019
		Time (Wilks' Lambda)	25.69	<0.0001
		Group*Time (Wilks' Lambda)	1.46	0.2163
	Tests of Hypotheses for Between Subjects Effects	Group	10.00	0.0019
	Univariate Tests of Hypotheses for Within Subject Effects	Time	29.27	<0.0001
		Group*Time	1.68	0.1519
	Comparison of between Machine at each time point	Time1 (0 h)	0.03	0.8723
		Time 2 (2 h)	7.81	0.0058
		Time 3 (12 h)	7.56	0.0066
		Time 4 (24 h)	4.65	0.0324
		Time 5 (72 h)	3.16	0.0775
	Analysis of Variance of Contrast Variables			
	Time2 vs Time1	Mean Trend	79.37	<0.0001
		Group	5.70	0.0181
	Time3 vs Time1	Mean Trend	72.58	<0.0001
		Group	2.33	0.1288
	Time4 vs Time1	Mean Trend	51.78	<0.0001
		Group	1.15	0.2853
	Time5 vs Time1	Mean Trend	29.27	<0.0001
		Group	0.88	0.3506

because lower FiO_2 was used, the optimal adjustment of FiO_2 and PEEP in the observation group resulted in a favorable improvement in the PaO_2/FiO_2 ratio from postoperative 12 h and a difference in the PaO_2/FiO_2 ratio between the two groups in the presence of an insignificant difference in PaO_2, confirming the benefit of the optimized oxygen therapy regimen.Table 7 reveals that there was no difference in PaO_2 between the two groups throughout the study period, but a significant difference was observed in the PaO_2/FiO_2 ratio. The analysis suggests that effectively reducing FiO_2 can decrease inflammation (both AAD and extracorporeal circulation can induce inflammatory responses) and oxidative stress reactions in patients, thereby improving effective oxygenation.At 2 h and 12 h postoperatively, the difference in PH between the two groups was statistically significant, indicating that the adjustment in the observation group improved the respiratory function of patients better, resulting in a reduction in PH. $PaCO_2$ was significantly lower in the observation group at 2 h, 12 h, and 24 h postoperatively, indicating that the modified regimen enhanced the breathing function of patients and led to effective CO2 clearance, thereby decreasing $PaCO_2$.In both groups, the time effect of changes in PH, $PaCO_2$, oxygenation index, and PaO_2 was statistically significant, while the time effect of $PaCO_2$ was statistically significantly different between the two groups. This suggests that decreasing FiO_2 and increasing PEEP can successfully enhance oxygenation and breathing in patients.Our research demonstrates that it is viable to preload FiO_2 to 60% and PEEP to 5 cmH_2O after AAD surgery, and that PEEP can be extended to 10 cmH2O in patients with preoperative hypoxemia. Blood gas analysis should be performed within 30 min of any change in mechanical ventilation parameters in order to quickly modify parameters.To avoid the negative impact of high positive

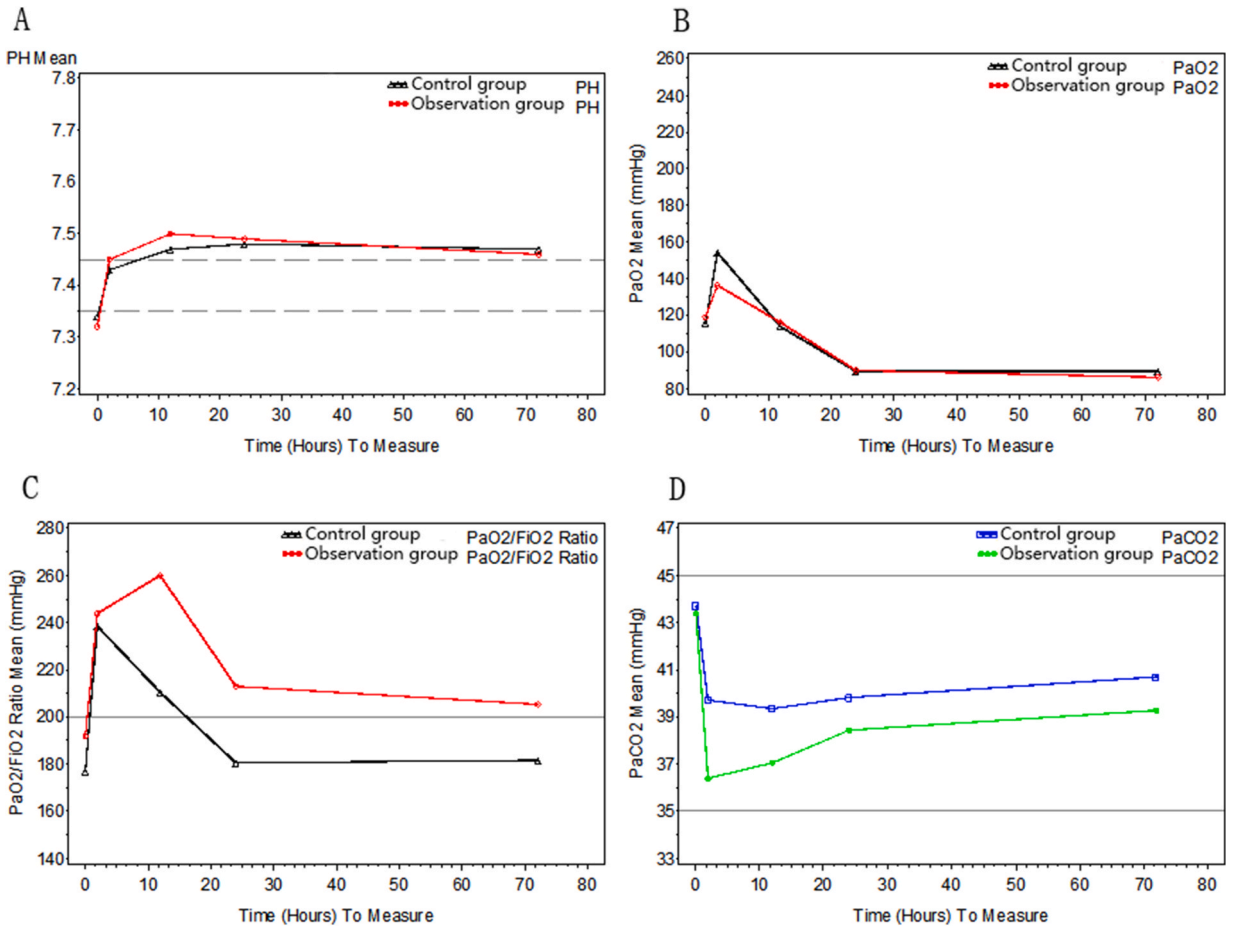

Fig. 2. Trend of Average pH,PaO2,PaO2/FiO2 Ratio and PaCO2 Change over Time by Groups.A Trend of Average pH Change over Time by Group.B Trend of Average PaO2 Change over Time by Group.C Trend of Average PaO2/FiO2 Ratio Change over Time by Group.D Trend of Average PaCO2 Change over Time by Group.

end-expiratory pressure (PEEP) on cardiac output, we also collected and analyzed data on patient central venous pressure (CVP) and blood pressure. The data showed that there was no statistically significant difference in CVP between the group who underwent aortic dissection surgery and used higher PEEP, compared to the control group. Additionally, there was no statistically significant difference in blood pressure between the two groups.

Consistent with the study by Kapil et al. [26], in this study, we required a tidal volume of 6–8 mL/kg ideal body weight for lung-protective breathing. Despite this, medical personnel prefer 8 mL/kg expected body weight over 6 mL/kg predicted body weight when setting starting parameters, which explains the relatively large number of patients with alkaline PH after surgery.Patients enrolled in this study had a mean body mass index of 26.84, highlighting the importance of predicting tidal volumes based on expected body weight.The current study demonstrates that the presence of hyperoxemia in patients with extracorporeal circulation and pulmonary ischemia-reperfusion injury is associated with the development of cognitive dysfunction postoperatively in patients [27]. In addition to hypoxemia, postoperative hyperoxemia occurred in this study, with the highest values of 4.4% in the control group at 2 h after patients returned to the cardiac ICU and 3.6% in the observation group immediately after surgery (Table 2), indicating that there is still a gap in the understanding and management of PaO_2, SpO_2, and FiO_2 by the doctor and nurse teams, and that clear target ranges should be established. SpO_2 levels between 94% and 98% are often recommended for patients without hypercapnia, while SpO_2 levels between 88% and 92% are recommended for patients at risk of hypercapnic respiratory failure [28].

Early extubation can substantially prevent postoperative pulmonary problems and ensure speedy recovery, and 3–8 h following cardiac surgery is the optimal period for extubation [29]. The use of higher oxygen inhalation concentrations is not conducive to the early weaning and extubation of patients; therefore, the ventilator settings should be lowered early.A nurse-led protocol for ventilator adjustment and patient extubation facilitates this process [17].In the current study, correction of hypoxemia did not significantly reduce patient mortality, however the gold standard for clinical management remains lung-protective ventilation strategy. Low tidal volumes, acceptable PEEP, FiO_2 restriction, and airway plateau pressure can achieve adequate oxygenation while reducing ventilator-induced lung injury [30].

The concept of using higher FiO_2 in AAD patients after CPB surgery is deeply ingrained, with a high tolerance for hyperoxemia.

However, the risks associated with hyperoxemia, such as increased ischemia-reperfusion injury, compromised microcirculation and tissue oxygenation, elevated frequency of delirium and cognitive dysfunction, prolonged hospital and ICU stays, and increased mortality rates [12], are receiving increasing attention. In this context, conducting this study is necessary. For AAD patients, mechanical ventilation as an auxiliary ventilation measure is essential. The adjustment of its parameters involves the participation of multiple clinical healthcare professionals such as physicians, respiratory therapists, and nurses, making it complex. The decision-making authority in this regard varies significantly among different institutions, leading to a systematic challenge in the correct understanding and use of FiO_2 postoperatively for AAD patients. The study shows that the preset and adjustment of FiO_2 overall tend to be conservative. This is reflected in the average FiO_2 values of 62% in the observation group and 66% in the control group. Future research protocols should take larger steps in this regard. Through these studies, the staff at the center have come to realize that high oxygen levels are not always beneficial; achieving target SpO_2 and PaO_2 levels is more appropriate.

6. Limitations

This study had three significant limitations. First, this study was a quasi-randomized, single center-controlled trialin which all patients were from the Department of Cardiovascular Surgery at The Second Hospital of Shandong Universty, Jinan, China.The sample size was limited,and Moreover, patients did not receive follow-up after discharge.so the participating institutions may not have been representative of the entire region.

Second, because this study's data variables were retrieved from intensive care records, there were no records on the size of false lumens and the extent of the dissection tear. As a result, the disease severity of patients cannot therefore be graded. Third, general patient information was extracted from the system, introducing the possibility of bias in some data. Notably, this is the first attempt to individualize the adjustment of ventilation and oxygenation parameters in patients with AAD receiving mechanical ventilation after surgery.We need to design a multicenter prospective analysis in the future to further verify our results.

7. Conclusion

After surgery, the presetting of mechanical ventilation parameters in patients with AAD requires uniform criteria. Initial tidal volume can be adjusted to 7 mL/kg ideal body weight, FiO_2 can be set to 60%, and PEEP can be set to 5 cmH_2O. Parameter adjustments for oxygenation goals should focus on rapid decreases in $FiO_2$and prioritized increases in PEEP. In most critically ill patients, the minimal FiO_2 required for the oxygenation goal, should be met.

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Ethics approval and consent to participate

This study was conducted in accordance with the declaration of Helsinki.This study was conducted with approval from the Ethics Committee of The Second Hospital of Shandong University (No.:KYLL-2019 (KJ) P-0200).A written informed consent was obtained from all participants.

Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Li Wang: Writing – original draft, Data curation, Conceptualization. **Xinyan Pang:** Formal analysis, Data curation. **Shouluan Ding:** Writing – original draft, Formal analysis, Data curation. **Ke Pei:** Software, Formal analysis, Data curation. **Zijia Li:** Software, Formal analysis, Data curation. **Jianhong Wan:** Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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