ACUTE RESPIRATORY DISTRESS SYNDROME: RAPID AND SIGNIFICANT RESPONSE TO VOLUME-CONTROLLED INVERSE RATIO VENTILATION

- A Case Report-

Nahid Aghdaii*, Seyede Zahra Faritous**,
Forouzan Yazdanian** and Halime Reza Zade***

Abstract

Pulmonary complications following cardiopulmonary bypass (CPB) are relatively common, with up to 12% of patients experiencing acute lung injury (ALI). The treatment for ALI or acute respiratory distress syndrome (ARDS) is primarily supportive with specific modes of mechanical ventilation. We report a 46-year-old man with ARDS after cardiac surgery whose arterial oxygenation was surprisingly improved 1 hour after using volume-controlled inverse ratio ventilation (VC-IRV).

Key words: pulmonary complication, CABG, treatment of ARDS.

Introduction

Pulmonary complications following cardiopulmonary bypass (CPB) are relatively common, with up to 12% of patients experiencing acute lung injury (ALI). The overall goals of mechanical ventilation in ARDS are: to maintain acceptable gas exchange and to minimize the occurrence of adverse effects associated with its application.

A growing consensus currently supports the use of low tidal volume ventilation, with positive end expiratory pressure (PEEP)[1,2,4]. Current clinical practice with known or suspected lung injury is, however, to limit inflation pressure. The inverse ratio ventilation (IRV) is a mode of mechanical ventilation in which the inspiratory time is prolonged ($I \geq E$) and has the advantage over the conventional use of ($E \geq I$ and extrinsic-PEEP) in that unacceptable increases in peak airway pressures and peak alveolar pressures can be avoided[3].

From Shahid Rajaii Heart Center, Iran University of Medical Sciences, Tehran, Iran.
* MD, Assoc. Prof. of Anesthesiology.
** MD, Assist. Prof. of Anesthesiology.
*** Superviser of Cardiac-ICU.
Corresponding author: Nahid Aghdaii MD, Depart. of Anesthesiology, Shahid Rajaii Cardiovascular Medical Center, Iran University of Medical Sciences, Tehran-Iran. Tel: 23922148, Fax: 22663293, E-mail aghdaii@yahoo.com

Table 1
ABG Results

ABG results (arterial blood gas)	ABG Result 1	ABG Result 2	ABG Result 3	ABG Result 4	ABG Result 5	ABG Result 6
pH	7.34	7.39	7.31	7.48	7.35	7.44
PO_2	50	37	69	115	182	66
O_2 saturation	82	68	92	98	100	94
PCO_2	41	32	39	35	37	35
HCO_3	22	19	26	26	20	23
Total CO_2	23	20	27	27	21	24
B.E	-3	-5	3	4	-4	0

ABG result 1 - despite O_2 supplementation,
ABG result 2 - after re-intubation
ABG result 3 - with high PEEP levels and low tidal volume,
ABG result 4 - with IRV
ABG result 5 - with supplemental O_2 the day of discharge from ICU.
ABG result 6 - without supplemental O_2 on the day of discharge from ICU.

Table 2
Scoring Acute Lung Injury

Points	0	1	2	3	4
CXR No of quadrants	No infiltration	One	Two	Three	All four
PaO_2/FiO_2	≥300	225 to 299	165 to 224	100 to 174	<100
PEEP cmH_2O	≤5	6 to 8	9 to 11	12 to 14	>15
Cstat	≥80	60 to 79	40 to 59	20 to 39	≤19

Final score = aggregate Sum/No. of components assessed.
(0 = No lung injury; 0.1 to 2.5 = Acute lung injury; >2.5 = Adult respiratory distress syndrome).

Case Report

A 46-year-old man, with a 5 year history of ischemic heart disease, hypertension and severe opium addiction and a 15 year history of heavy smoking, with EF = 50% and three vessels disease, was operated for coronary artery bypass graft (CABG) surgery, under cardiopulmonary bypass (CPB). The operation was uneventful.

After operation, in the ICU, because of bleeding with chest tube drainage in place, patient was sedated. Following reduction of drainage, weaning of patient from ventilator was gradually started. The day after, patient was completely weaned and was extubated.

Thirty six hours after extubation, however, he suddenly had an acute onset of severe arterial hypoxemia resistant to oxygen therapy. Meanwhile, the hemodynamics were stable, ECG did not show arrhythmia or ischemia, echocardiography did not show evidence of left ventricular failure. At this time (arterial pressure of oxygen) PaO_2/FIO_2 (fraction of inspiratory oxygen) was<100 (Table1-ABG1).

The patient was rapidly intubated, sedated and ventilated with conventional ventilator support that is usually used following surgery(Volume cycled, SIMV, RR = 12/min, Vt = 10cc/kg, FiO_2 = 50%, I:E = 1:2, PS = 15 cm H_2O, PEEP = 5 cm H_2O) following cardiac surgery (Table1-ABG2).

Chest x.ray revealed bilateral infiltration of the lungs (3 quadrant at first and 4 quadrant 1 hour later).

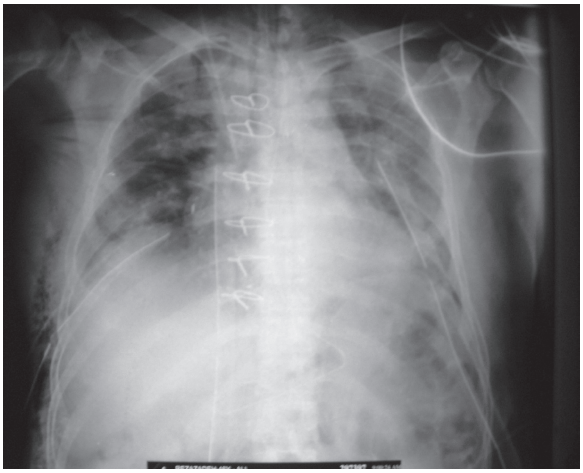
(chest-x-ray 1 and 2).

Based on Murray lung injury score[3] that awards points for affected quadrants on chest x-ray, PaO_2/FiO_2 ratio, amount of PEEP applied and static compliance of the lungs (Table 2) our patient's score was greater than 2.5, which confirmed severe ARDS. The ventilator's settings were therefore changed to high PEEP level with low tidal volume. With this setting arterial oxygenation was improved, PaO_2 reached to 61-63 mmHg and O_2 saturation reached to 93-94% (Table 1-ABG3).

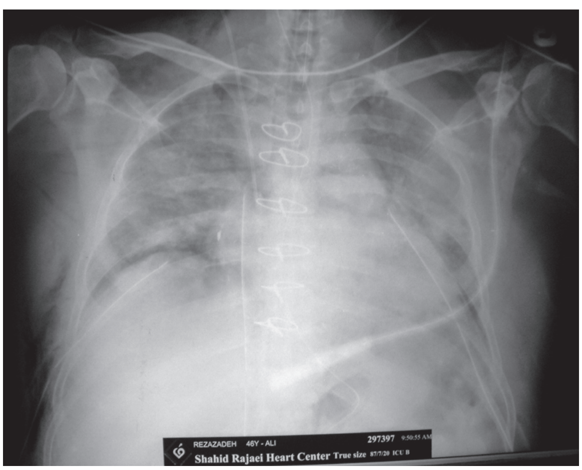
The same ventilation was maintained for the following 48 hour, but PaO_2 did not increase and emphysema began to show.

With this development, the ventilator's settings were modified to deliver inverse ratio ventilation (IRV) with reduction in ventilator rate and PEEP discontinued.. An hour later, PaO_2 reached up to 115 mmHg and arterial O_2 saturation (SaO_2) of 98% (Table 1-ABG 4).

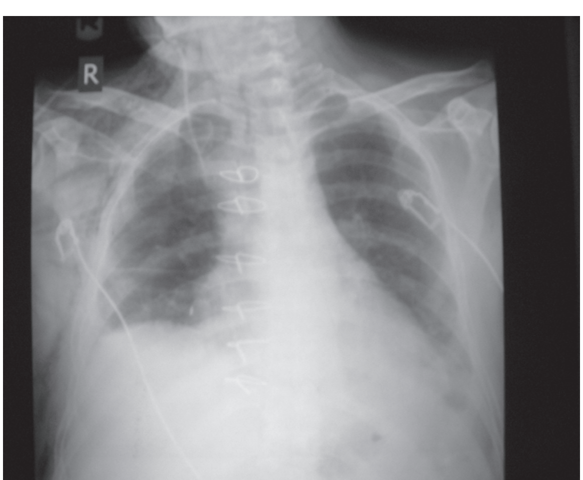
Weaning of patient was started, sedative drugs were tapered and surprisingly in 8 hour patient's status normalized and he was extubated. Emphysema was reduced in 48 hour. Patient was discharged from ICU with acceptable ABG (Table 1-ABG 5 & 6), chest-x-ray (chest-x-ray 3) and stable hemodynamics (MAP = 83mmHg, HR = 87 beat/min, no serious arrhythmias and EF = 45%).



Chest X Ray 1 (3 quadrant infiltration)



Chest X Ray 2 (4 quadrant infiltration)



Chest X Ray 3 (on the day of discharge from ICU)

Discussion

Patients undergoing cardiac surgery experience physiologic stresses from anesthesia, surgical manipulation, and CPB[4]. ARDS may develop as a sequel of CPB, or, more commonly, in the postoperative patient with cardiogenic shock, sepsis, or multiple organ failure[3].

The treatment for ALI or ARDS is primarily supportive with mechanical ventilation, a procedure allowing time for treatment of the underlying cause of lung injury and for natural healing[4]. Low tidal volume ventilation should be applied to all patients with ARDS unless more efficacious strategy is demonstrated[1].

For more than two decades, PEEP has been used to improve arterial oxygenation in patients with ARDS[2]. Indeed, several recent studies have found improved hemodynamic performance and fewer pulmonary complications using high PEEP levels with tidal volumes as low as 6 ml/kg in these patients[5-8].

Due to the increased physiologic dead space of patients with ARDS, ventilator rates greater than 20-25 breath/min are often required to normalize $PaCO_2$ and pH, unless excessive intrathoracic gas trapping occurs, leading to development of auto-PEEP which has the potential of advese effects including barotraumas, hemodynamic instability, increased work of breathing, and decreased efficiency of diaphragmatic contractility[2]. We also used this method (tidal volume = 6 ml/kg, PEEP + 8-15 cm H_2O, ventilator rate + 18-20 breath/min) on our patient but it could not increase PaO_2 to more than 69-74 mmHg.

Because of the preceding event and the start of emphysema (adverse effect of auto-PEEP), we changed the mode to volume-controlled-inverse ratio ventilation (VC-IRV). Other investigations have concluded that the effect of reduced expiratory time on end-expiratory lung volume, pressure and arterial oxygenation during volume-controlled VC-IRV, is similar to the use of PEEP[12-16]. However a growing clinical experience with the use of IRV suggests that it is a useful strategy for salvaging gas exchange in ARDS patients whose oxygenation cannot be maintained with more conventional approaches, and several hours may be required to achieve the maximal benefits of IRV on gas exchange.[2,4,9-12] An advantage of IRV over the conventional use of extrinsic-PEEP is that unacceptable increases in peak airway pressures and peak alveolar pressures can be avoided[17].

In our case, we could not highly improve arterial oxygenation with using of high PEEP levels and low tidal volume, but with the use of VC-IRV, oxygenation was rapidly and significantly improved while acceptable peak airway pressure was maintained.

Although beneficial effects of VC-IRV are known, and studies have been directed on the late effects of this mode of ventilation, yet the rapid and significant effect on oxygenation has not been reported.

Conclusions

In a situation where acceptable arterial oxygenation cannot be achieved with PEEP less than 15 cmH_2O, or when the use of PEEP is associated with excessive plateau pressure, the volume-controlled inverse ratio ventilation (VC-IRV) is recommended.

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