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The Effect and Safety of Alveolar Recruitment Maneuver using Pressure-Controlled Ventilation in Acute Lung Injury and Acute Respiratory Distress Syndrome

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Background: Alveolar recruitment (RM) is one of the primary goals of respiratory care for an acute lung injury (ALI) and acute respiratory distress syndrome (ARDS). The purposes of alveolar recruitment are an improvement in pulmonary gas exchange and the protection of atelectrauma. This study examined the effect and safety of the alveolar RM using pressure control ventilation (PCV) in early ALI and ARDS patients.

Methods: Sixteen patients with early ALI and ARDS who underwent alveolar RM using PCV were enrolled in this study. The patients' data were recorded at the baseline, and 20 minutes, and 60 minutes after alveolar RM, and on the next day after the maneuver. Alveolar RM was performed with an inspiratory pressure of 30 cmH₂O and a PEEP of 20 cmH₂O in a 2-minute PCV mode. The venous O₂ saturation, central venous pressure, blood pressure, pulse rate, PaO₂/FiO₂ ratio, PEEP, and chest X-ray findings were obtained before and after alveolar RM.

Results: Of the 16 patients, 3 had extra-pulmonary ALI/ARDS and the remaining 13 had pulmonary ALI/ARDS. The mean PEEP was 11.3 mmHg, and the mean PaO₂/FiO₂ ratio was 130.3 before RM. The PaO₂/FiO₂ ratio increased by 45% after alveolar RM. The PaO₂/FiO₂ ratio reached a peak 60 minutes after alveolar RM. The PaCO₂ increased by 51.9 mmHg after alveolar RM. The mean blood pressure was not affected by alveolar RM. There were no complications due to pressure injuries such as a pneumothorax, pneumomediastinum, and subcutaneous emphysema.

Conclusion: In this study, alveolar RM using PCV improved the level of oxygenation in patients with an acute lung injury and acute respiratory distress syndrome. Moreover, there were no significant complications due to hemodynamic changes and pressure injuries. Therefore, alveolar RM using PCV can be applied easily and safely in clinical practice with lung protective strategy in early ALI and ARDS patients. (*Tuberc Respir Dis* 2007;63:423-429)

Key Words: Recruitment maneuvers, Acute lung injury, Acute respiratory distress syndrome, Pressure-controlled ventilation

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서론

Amato The Acute Respiratory Distress Syndrome Network trial

(< 6 ml/kg)

^{1,2}

(alveolar recruitment maneuver)
 (Positive End-Expiratory Pressure)
 (opening and cycling collapse)
 ALVEOLI (Assessment of Low tidal Volume and Elevated end-expiratory pressure to Obviate Lung Injury) trial

20 / (respon-
 50% der) , 50%
 (non-responder)

2. 연구 방법

3,4
 Lim 5,6
 가
 가
 7

(closed suction catheter)
 가
 (arterial line) (central venous pressure) (venous oxygen saturation) (jugular vein)
 (subclavian vein)
 6~8
 ml/kg
 (FiO₂) 0.6 (PaO₂) 60 mmHg (SaO₂) 90%
 30 cmH₂O
 30

대상 및 방법

1. 연구 대상

2007 2

가
 ,
 , 30
 cmH₂O 20 cmH₂O
 50 cmH₂O 2
 20 , 60
 ,
 . 20 /
 ALVEOLI trial⁴

American-European Consensus Conference⁸
 (CR-4-2006-0283)
 (CR-2007-12)

(Table 1). ,
 30 cmH₂O가
 6

3. 통계 분석

SAS 9.1

, p-value가 0.05

가
±
student t-test ,
Wilcoxon rank sum test
chi-square test

Table 1. Application of PEEP

FiO ₂	Lower PEEP group (cmH ₂ O)	Higher PEEP group (cmH ₂ O)
0,3	5	12~14
0,4	5	14
0,4	8	16
0,5	8	16
0,5	10	18~20
0,6	10	20
0,7	10	20
0,7	12	20
0,7	14	20
0,8	14	20~22
0,9	14	22
0,9	16	22
0,9	18	22
1,0	20	22
1,0	22	22
1,0	24	24

20, 60, (Fried-
man test) 가

결 과

1. 대상 대상자의 임상적 특성

16, 11, 5
61.0±11.8, APACHE II
score 21.6±11.9, SAPS score 44.6±14.0

Table 2. Clinical characteristics of subjects before recruitment

No.	Sex (M/F)	Age (years)	Interval (day) from ALI/ARDS to RM	Causes of ALI/ARDS	APACHE II	SAPS	PEEP (cmH ₂ O)	PaO ₂ /FiO ₂
1	M	43	1	Sepsis	10	30	10	262,5
2	M	64	2	Pneumonia	16	56	10	187,0
3	M	61	1	Pneumonia	22	32	14	81,0
4	M	56	2	Pneumonia	62	26	10	94,3
5	M	70	3	Sepsis	21	64	13	178,8
6	F	67	1	Pneumonitia	19	42	10	145,0
7	F	65	1	Pneumonia	26	55	10	151,0
8	F	36	2	Pneumonia	20	41	13	140,4
9	M	65	1	Pneumonia	20	53	14	54,3
10	M	72	2	Pneumonia	13	30	12	112,8
11	F	77	2	Pneumonia	23	69	12	68,9
12	M	56	2	Sepsis	10	25	10	224,9
13	M	72	3	Pneumonia	28	41	10	140,7
14	M	68	2	Pneumonia	16	38	10	65,8
15	M	68	1	Pneumonia	18	60	12	103,0
16	F	47	1	Pneumonia	22	51	11	74,7
Mean±SD		61,0±11,8	1,7±0,7		21,6±11,9	44,6±14,0	11,3±1,5	130,3±60,2

PEEP: positive end-expiratory pressure; RM: recruitment maneuver; ALI: acute lung injury; ARDS: acute respiratory distress syndrome.

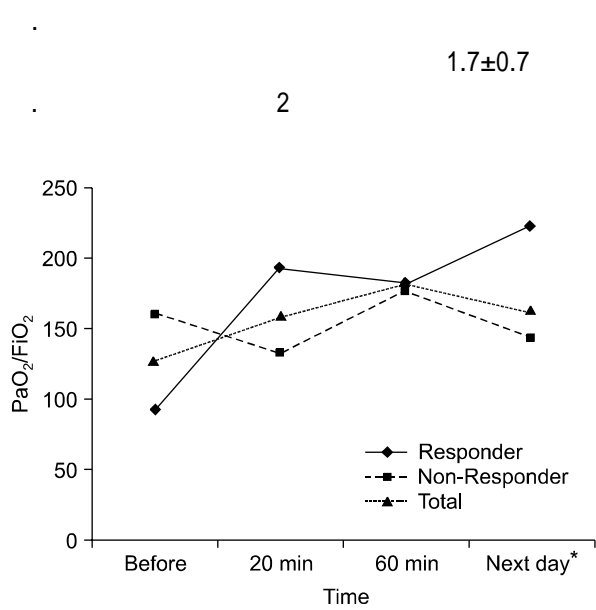


Figure 1. Change of PaO₂/FiO₂ ratios (median value) at baseline, and 20 mins, 60 mins, and on the next day after the Alveolar RM of Responders, Non-responders and Total Subjects. *Average 10 hours after recruitment maneuver.

14
가 13
3
11.3±1.5 mmHg
130.3±60.2 (Table 2).

2. 폐포모집술 시행 전 · 후의 동맥혈가스 검사 결과의 변화

60 가 (Figure 1),
60
가 (Table 3).
10 가

Table 3. Change of PaO₂/FiO₂ before RM and 20 mins, 60 mins, next day after RM

	Pre-RM	20 mins after RM	60 mins after RM	Next day*	p-value
RESPONDER (N=8)					
PaO ₂ /FiO ₂	92.0 (65.8~151)	193.2 (108.7~378.3)	183.1 (117.8~364)	223.7 (110~330)	<.001
PaCO ₂ (mmHg)	38.2 (29.4~52.9)	52.8 (30.4~97.3)	52.7 (35.8~62.2)	42.2 (32.6~56.9)	0.10
SvO ₂ (%)	82.7 (69.8~99.6)	90.0 (69.3~94.6)	86.8 (75.8~94.1)	86.0 (74.8~90.)	0.22
NON-RESPONDER (N=8)					
PaO ₂ /FiO ₂	159.6 (54.3~262.5)	133.9 (54.8~308.875)	176.6 (68.1~285)	143.2 (87.6~352.8)	0.44
PaCO ₂ (mmHg)	42.6 (21~56.5)	43.2 (28~64.9)	43.4 (26.4~61.6)	42.6 (29.1~55.7)	0.28
SvO ₂ (%)	84.2 (66.1~92)	79.4 (71.9~93)	82.1 (72.7~93)	83.0 (66.9~89.5)	0.23
Total (N=16)					
PaO ₂ /FiO ₂	126.6 (54.3~262.5)	158.7 (54.8~378.3)	183.1 (68.1~364)	163.0 (87.6~352.8)	<0.01
PaCO ₂ (mmHg)	42.3 (21~56.5)	44.8 (28~97.3)	51.9 (26.4~62.2)	42.6 (29.1~56.9)	0.05
SvO ₂ (%)	83.7 (66.1~99.6)	85.8 (69.3~94.6)	85.5 (72.7~94.1)	85.0 (66.9~90)	0.11

RM: recruitment maneuver.
All values were represented by median (minimum~maximum).
*average 10 hours after recruitment maneuver.

Table 4. Change of hemodynamic parameters before RM and 20 mins, 60 mins, next day after recruitment maneuver

	Before-RM	20 mins after RM	60 mins after RM	Next day*	p-value
RESPONDER (N=8)					
SBP (mmHg)	121.0 (105~156)	109.5 (103~123)	105.5 (78~126)	121.5 (102~168)	0.28
MBP (mmHg)	82.5 (65~94)	70.0 (64~85)	70.5 (56~90)	82.0 (52~110)	0.11
HR (/min)	102.0 (66~141)	96.0 (71~165)	99.0 (72~146)	90.0 (69~130)	0.42
NON-RESPONDER (N=8)					
SBP (mmHg)	125.0 (100~135)	115.0 (104~140)	109.0 (101~130)	126.0 (73~150)	0.07
MBP (mmHg)	81.0 (64~98)	81.0 (66~93)	83.0 (64~90)	88.5 (58~120)	0.47
HR (/min)	118.5 (81~144)	114.5 (92~144)	111.5 (87~143)	113.5 (92~129)	0.63
Total (N=16)					
SBP (mmHg)	122.5 (100~156)	112.5 (103~140)	107.0 (78~130)	126.0 (73~168)	0.02
MBP (mmHg)	82.5 (64~98)	75.5 (64~93)	80.0 (56~90)	85.0 (52~120)	0.08
HR (/min)	108.5 (66~144)	104.0 (71~165)	107.0 (72~146)	107.5 (69~130)	0.29

RM: recruitment maneuver; SBP: systolic blood pressure; MBP: mean blood pressure; HR: heart rate.

All values were represented by median (minimum~maximum).

*average 10 hours after recruitment maneuver.

3. 폐포모집술 전·후의 혈역동학적인 변화

60
가
가 (Table 4).

4. 폐포모집술의 부작용

60 60 mmHg

고 찰

(cyclic collapse and opening)

가

9

3.4

Lim

10

Kim¹¹

가 Ana Villagra

12, 17

가 가 가 가 가
 (upper inflation point) 3 cmH₂O (lung mechan-
 ics)
 15
 / 20%
 가 가

요 약

가 가 연구배경:
 가 가
 가 17 8
 가 15 가 30 cmH₂O
 가 13 Ana Villagra 20 cmH₂O 2
 X-ray
 결 과: 16 , 3
 13
 60 가 (shunt) 61.0±11.8 , APACHE II score 21.6±
 11.9 , SAPS score 44.6±14
 , 11.3±1.5 mmHg
 / 130.3±60.2
 20 , /
 50%
 (minute ventilation) 50% 8 8
 , APACHE II score, SAPS score,
 / 가
 , /
 (p<0.001).
 60
 (p=0.05).

(p=0.08).

결 론:

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