机械通气时
肺开放/复张的临床应用

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- 肺复张：在机械通气过程中间断给与高于常规平均气道压的压力并维持一定的时间，让萎陷的肺泡复张，即肺开放（Open lung approach, OLA)/复张策略（RM）

- RM
  - 改善氧合
  - 提高肺顺应性
  - 减少ALI

保护性通气策略 如低VT(5～6ml/kg)、PIP↓、PHC等

↓

增加肺泡萎陷，低氧血症↑

↓

应用最佳PEEP→减少VALI和提高氧合等

通常用于保持肺泡复张的压力<使肺泡开放的压力

RM（较高气道正压使肺泡开放）+PEEP（维持肺泡开放）

↓

减少Q_S/Q_T、改善氧合、减少肺泡反复开/闭的剪切力所致的VALI

RM的方法

1. **控制性肺膨胀（SI）**

   可通过CPAP、PCV和BiPAP模式

   压力水平多在35～60cmH_2O，维持15 ～ 20s。

   一般认为30～45cmH_2O，维持20 ～ 30s是安全的。

2. **高PEEP**

   PEEP水平可高达40cmH_2O，Pplat至60cmH_2O

3. **叹息**

   sighs/min, Pplat45cmH_2O, for 1 hour.

4. **压力控制法（PCV）**

   高压40cmH2O, 低压16-20cmH2O, 维持90-120秒，呼吸频率不变。

5. **俯卧位通气（PPV）**

   对ALI患者在仰卧位采用RM，之后转为俯卧位。

俯卧位通气

Should Prone Positioning Be Routinely Used for Lung Protection During Mechanical Ventilation?

Henry E Fessler MD and Daniel S Talmor MD

[Respir Care 2010;55(1):88–96. © 2010 Daedalus Enterprises]

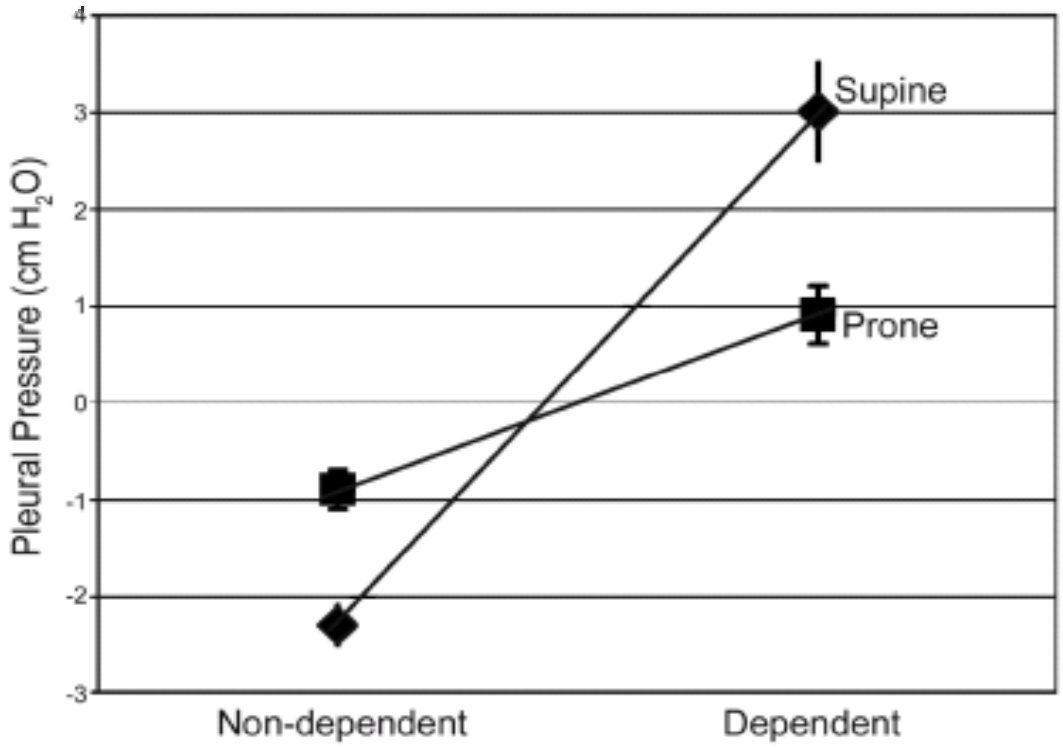
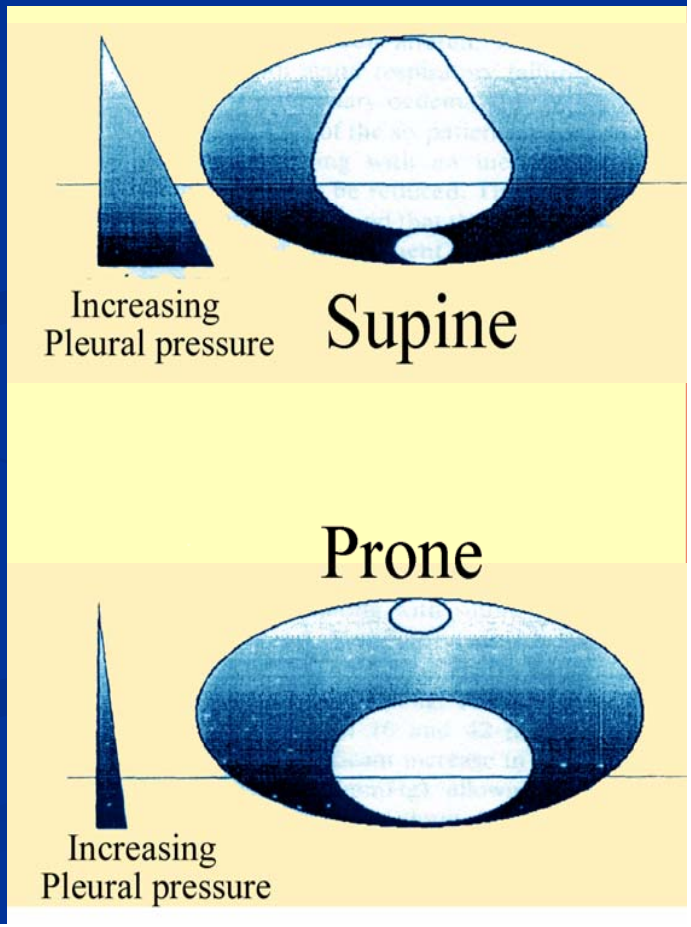


Fig. 1. Pleural pressure in dependent and non-dependent lung regions in supine and prone pigs after volume expansion. (Based on data in Reference 6.)



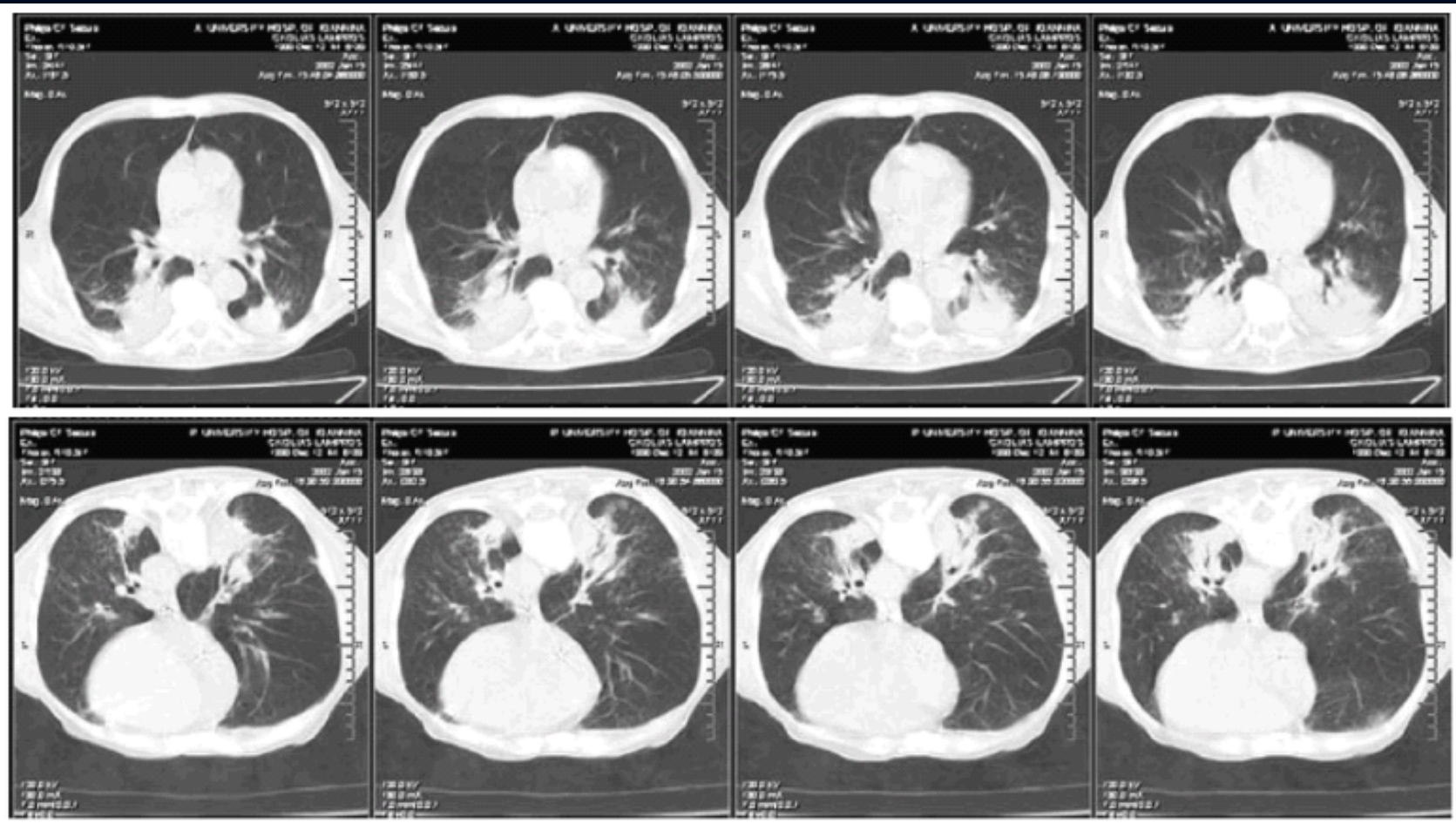


Fig. 3. Computed tomograms from a patient with acute respiratory distress syndrome in the supine and prone positions. Atelectatic dorsal lung regions are recruited in the prone position, without equivalent compression and derecruitment in ventral regions. (From Reference 40, with permission.)

我们曾作的相关工作:

1. 体位改变对急性肺损伤兔肺功能与CT及病理的影响 2005 中华结核和呼吸杂志 Vol 28, No 1

2.体位改变对兔急性肺损伤生理和病理的影响 2006 中国病理生理杂志 Vol 26, No 3

存在的问题

1. 吸气压（平台和平均气道压）：引起气压伤及对血流动力学影响？
2. 高PEEP：对VALI的影响？是否增加细菌移位种植危险？
3. 对已经应用高VT和高PEEP的患者，其肺组织可能已经达到了“最大”的复张水平，对RM反应差。

RM效果评价

1. 氧合与血流动力学变化
2. P-V曲线
3. 胸廓CT等

实验及临床应用的肺复张方法

Table 1

Description of the different methods used in experimental and human studies to perform recruitment maneuvers

Methods	Study	References
Continuous positive airway pressure at 30–60 cmH_2O for 15–60 s	Saline lavage, oleic acid, and pneumonia in animals	[15–20,54]
Pressure controlled mode: peak inspiratory pressure at 60 cmH_2O and end-expiratory pressure at 40 cmH_2O for 2 min	Saline lavage in animals	[18,20]
Volume controlled mode: 20 breaths at tidal volume of 20 ml/kg	Anesthetized healthy animals	[21]
Continuous positive airway pressure at 30–45 cmH_2O for 15–20 s	Anesthetized healthy patients	[23,26]
Pressure controlled mode: peak inspiratory pressure at 30–40 cmH_2O and end-expiratory pressure at 10–20 cmH_2O for 1 min	Anesthetized healthy patients	[24,25,27]
Sighs with a tidal volume to reach 45 cmH_2O plateau pressure	ARDS patients	[29,40]
Continuous positive airway pressure at 30–45 cmH_2O for 4–40 s	ALI/ARDS patients	[30,32,38,39]
Extended sigh with a tidal volume to reach 40 cmH_2O and end-expiratory pressure at 35 cmH_2O for 1 min	ARDS patients	[31]
Pressure controlled mode: peak inspiratory pressure at 40–60 cmH_2O and end-expiratory pressure at 10–30 cmH_2O for 30–120 s	ARDS/brain injury patients	[33,36,37]
Pressure support mode: peak inspiratory pressure at 40 cmH_2O and end-expiratory pressure for 30 s	ALI/ARDS patients	[35]

ALI, acute lung injury; ARDS, acute respiratory distress syndrome.

肺复张治疗
Studies Using Varied RM

RM method	Outcome
ARDSnet + 35-40 cm H2O CPAP for 40 sec.	variable effect on SpO2
ARDSnet + 35-40 cm H2O CPAP for 30 sec.	significant gravity dependent lung densities on CT, incomplete recruitment
3 sighs/min at 45 cm H2O Pplat for 1 hour	decreased shunt, increased EELV
CPAP 45 cm H2O for 20 seconds	improved PaO2, hypotension
Decreased VT + increased PEEP	increased PaO2, persisted > 1 hour
PEEP up to 40, Pplat up to 60 cm H2O	Improved PaO2
40 cm H2O CPAP for 40 sec.	Responders PaO2 increase > 50%
	in early ARDS and without
	impaired Ccw

Table 3—*Different Lung Recruitment Maneuvers*

Recruitment Maneuver	Method
Sustained high-pressure inflation[51,56]	Sustained inflation delivered by increasing PEEP to 30-50 cm H_2O for 20-40 s
Intermittent sigh[59]	Three consecutive sighs/min with the tidal volume reaching a Pplat of 45 cm H_2O
Extended sigh[60]	Stepwise increase in PEEP by 5 cm H_2O above baseline with a simultaneous stepwise decrease in tidal volume over 2 min leading to implementing a CPAP level of 30 cm H_2O for 30 s
Intermittent PEEP increase[55]	Intermittent increase in PEEP from baseline to set level for 2 consecutive breaths/min
Pressure control + PEEP[57]	Pressure control ventilation of 10-15 cm H_2O with PEEP of 25-30 cm H_2O to reach a peak inspiratory pressure of 40-45 cm H_2O for 2 min

CPAP = continuous positive air pressure. See Table 1 legend for expansion of other abbreviation.

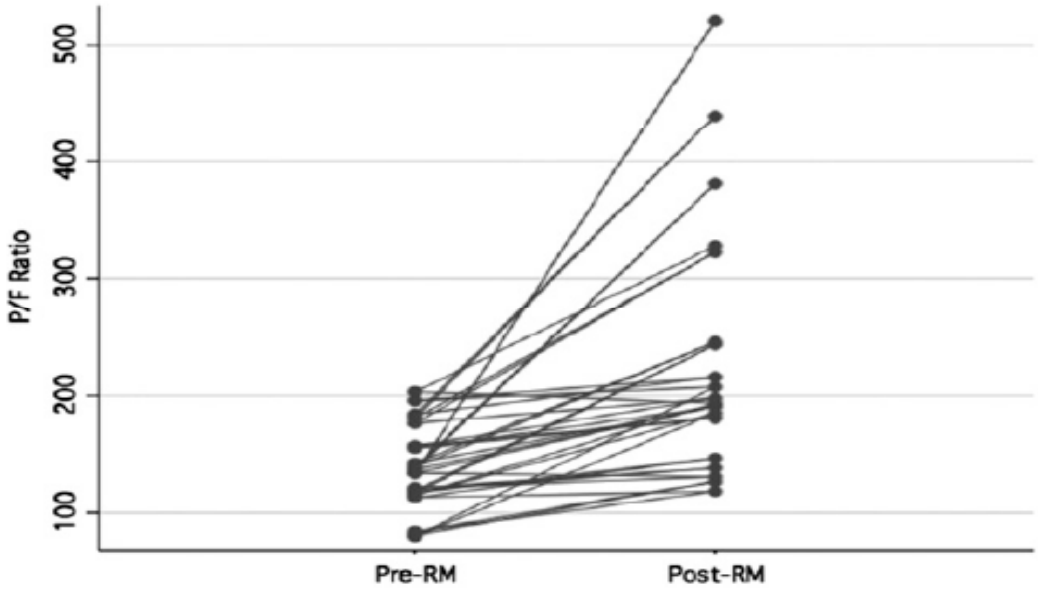


FIGURE 2. The relationship between oxygenation (PaO_2/FIO_2 ratio) after the application of a recruitment maneuver (post-RM) with baseline (pre-RM) oxygenation in each individual study presented. Oxygenation was significantly increased post-RM (PaO_2/FIO_2 ratio, 139 mm Hg vs 251 mm Hg; $P < .001$). P/F = PaO_2/FIO_2. (Reprinted with permission from the American Thoracic Society.[52])

Recruitment maneuvers for acute lung injury: a systematic review. Am J Respir Crit Care Med. 2008; 178(11): 1156

ATS 系统回顾分析1200例行RM的ALI/ARDS患者：

总体氧合得到明显改善，12%出现低血压，8%一过性低合下降，严重副作用为气压伤和心律失常各占1%。

对RM反应的影响因素：

复张前后PEEP(<5cmH2O vs >5cmH2O), 基础PaO2/FiO2(<150mmHg vs >150mmHg), 呼吸系统顺应性（<30ml/cmH2O vs >30ml/cmH2O)

Optimum PEEP

- Compliance, cardiac output, DO_2, decrease
- PaO_2 and FRC increase
- Deadspace increases ($PaCO_2$-$PetCO_2$)
- If PaO2 is unacceptable with high PEEP
  - fluid administration and pressors

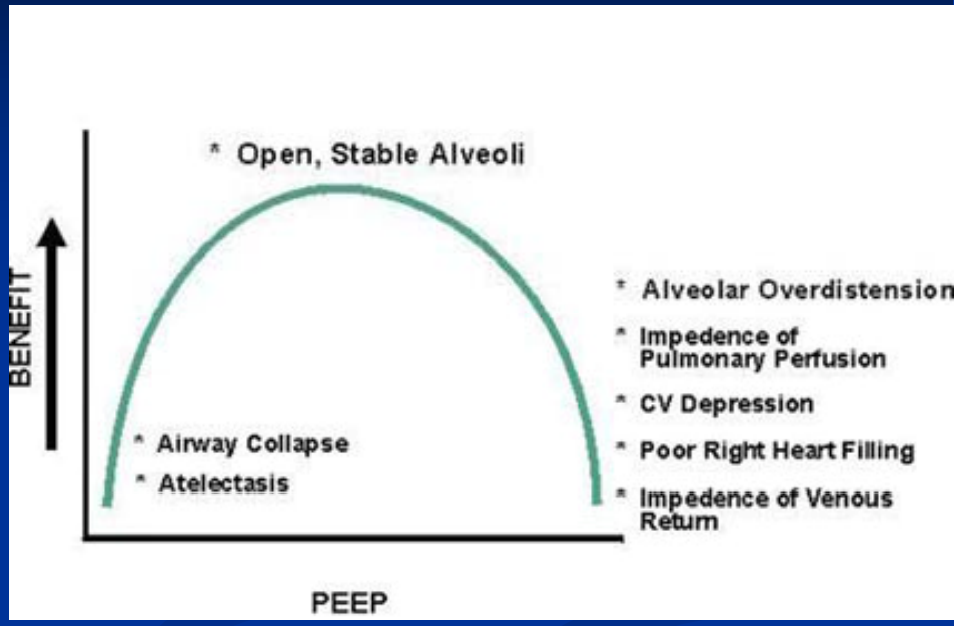


Table 2—*Methods for Selecting PEEP*

Method	Description
Incremental PEEP[3,27,39]	This approach uses combinations of PEEP and FIO_2 to achieve the desired level of oxygenation or the highest compliance.
Decremental PEEP[44,45]	This approach begins with a high level of PEEP (eg, 20 cm H_2O), after which PEEP is decreased in a stepwise fashion until derecruitment occurs, typically with a decrease in PaO_2 and decrease in compliance.
Stress index measurement[29]	The pressure-time curve is observed during constant-flow inhalation for signs of tidal recruitment and overdistension.
Esophageal pressure measurement[30,46]	This method estimates the intrapleural pressure by using an esophageal balloon to measure the esophageal pressure and subsequently determine the optimal level of PEEP required.
Pressure-volume curve guidance[51]	PEEP is set slightly greater than the lower inflection point.

See Table 1 for expansion of the abbreviation.

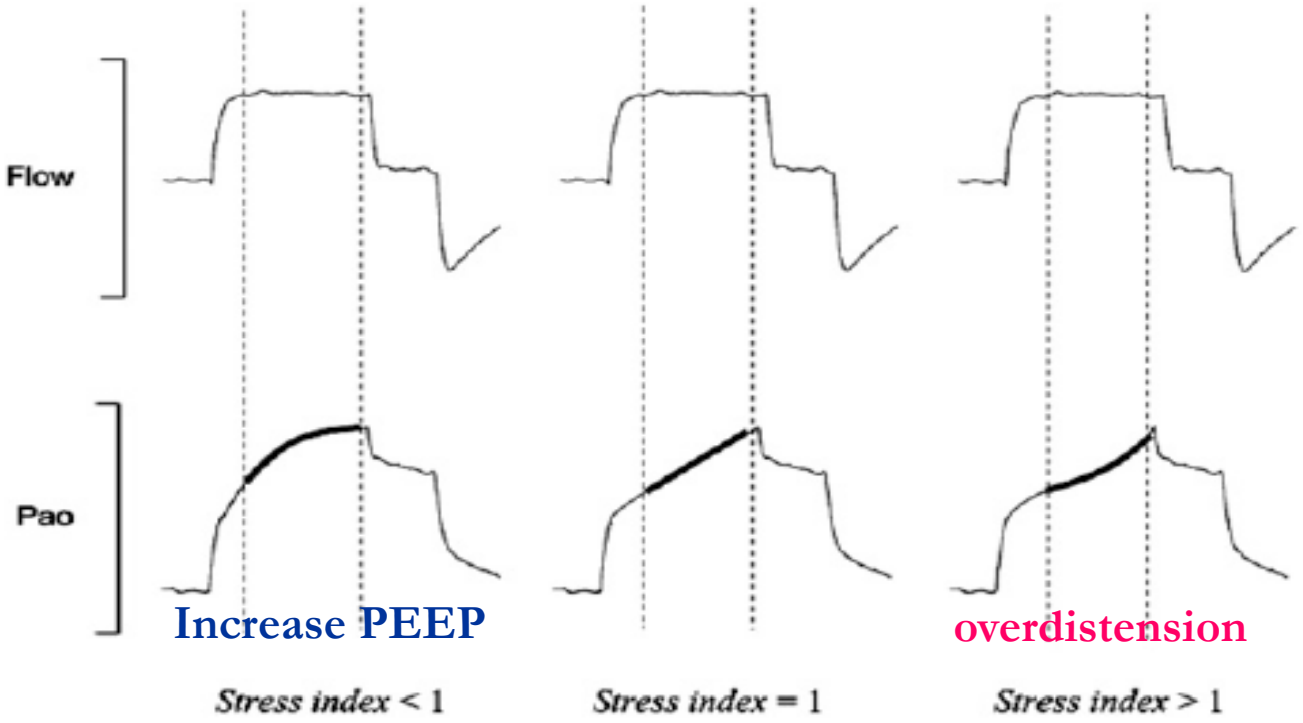


FIGURE 1. Graphic representation of the stress index. Flow and airway pressure vs time are displayed for three examples of stress index categories. The ventilator is set for constant-flow inflation. The stress index is derived from the airway pressure waveform between the dashed lines. For stress index values < 1, the airway pressure curve presents a downward concavity, suggesting a continuous decrease in elastance (or increase in compliance) during constant-flow inflation, and further recruitment of alveoli is likely. For stress index values > 1, the curve presents an upward concavity, suggesting a continuous increase in elastance (decrease in compliance), and excessive positive end-expiratory pressure may be present. Finally, for a stress index value $= 1$, the curve is straight, suggesting the absence of tidal variations in elastance. Pao = airway pressure. (Reprinted with permission from the American Thoracic Society.[29])

PCV vs SI RM

n=40

EFFECTS OF RECRUITMENT MANEUVERS ON OXYGENATION AND CENTRAL HEMODYNAMICS

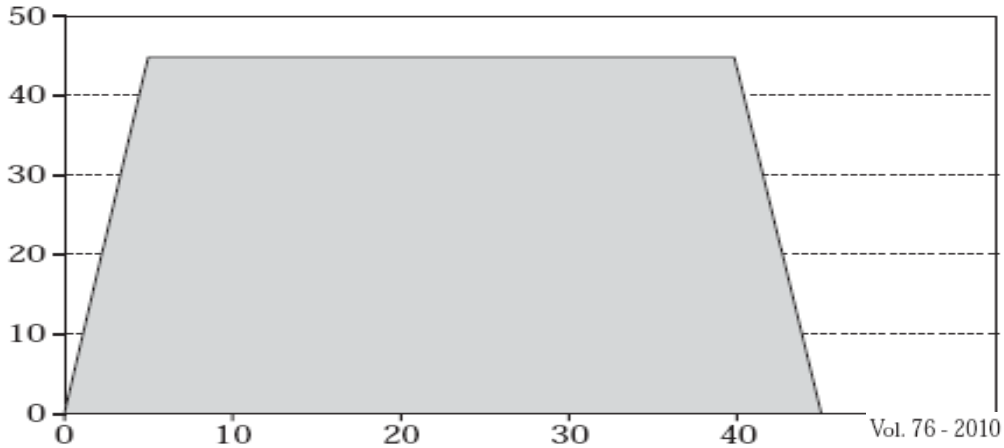


Figure 1.—Pressure-time product of sustained inflation (SI) recruitment maneuver. X axis: time (seconds); Y axis: pressure (cmH_2O).

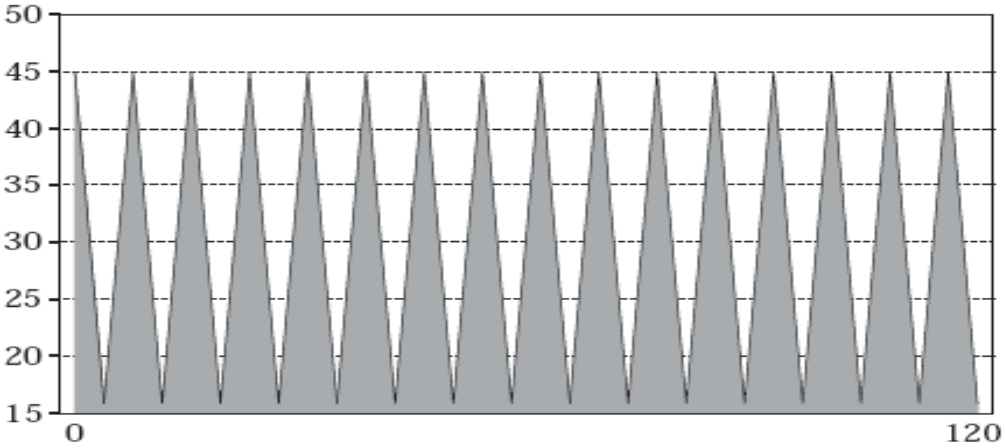


Figure 2.—Pressure-time product of pressure controlled ventilation (PCV) recruitment maneuver. X axis: time (seconds); Y axis: pressure (cmH_2O).

- **SI RM:Peak 45cmH2O for 40s**
- **PCV:Peak 45cmH2O for 2min**

I:E 1:2 PEEP 16 RR 8/min

MV strategy: 6mi/Kg FiO2 0.7

PEEP 14 RR14

Pplateau< 30cmH2O

MINERVA ANESTESIOLOGICA

Received on September 25, 2009; accepted for publication on March 12, 2010.

TABLE II.—*Hemodynamic variables before and after recruitment maneuvers (RM).*

Author	Pre-RM SI group	Post-SI RM group	Pre-PCV RM Group	Post-PCV RM
PaO_2 (mmHg)	86.3±23.7	105.2±31.5	88.2±20.2	157.6± 61.5*
P/F	141.8±40.7	165.7±44.4	155±30.8	238.8±86.5*
$PaCO_2$ (mmHg)	58±3.2	62±1.3	55±2.1	55±3.4
CRS	32±11.1	48±5.1	30±9.4	62±12.5*
Qs/Qt (%)	28.4± 5.8	23.5± 3.2		
	28.0± 5.8	17.3±9.7		
C.I. (L/min)	3.3±0.9	2.0±0.8*	3.2±0.5	3.4±0.8
PAOP (mmHg)	21.4±2.5	28.4±2.7*	20.4±2.3	19.7±2
MPAP (mmHg)	40.4±7.8	49.6± 2.8	40.2±5.7	30.2±3.5*
PVRI (dyne. sec. m^2/cm^5)	460.5± 64	848.6±12.4*	505 ±20.1	247±15.2
RVSWI (g.m/m2)	12±1.4	9.4±0.5	10.6 ±0.7	5.7±0.9*
CVP (mmHg)	17.4±2.5	20.4±2.7	18.1±1.8	19.7±2
Sys/Dia (mmHg)	108.5±14.3/53.5±12.4	89±6.5*; 49.5±9.2	105.5±15.5/58.2 ±10.4	106.5±13.1; 55.7±10.3
HR (bpm)	85.1±15.4	84.3±14.3	86±10.5	84.5±13.1

*P<0.05. SI: sustained inflation; PCV: pressure controlled ventilation; P/F: PaO_2 FiO_2 ratio; C.I.: cardiac index; PVR: pulmonary vascular resistance; CVP: central venous pressure; Sys/Dia: Systolic / Diastolic; HR: heart rate.

Conclusion. Given its comparable, or even superior, performance over the SI RM, we favor the PCV technique over the time-honored SI maneuver.

检测麻醉后病人肺顺应性和死腔率评价最佳PEEP

Compliance and Dead Space Fraction Indicate an Optimal Level of Positive End-Expiratory Pressure After Recruitment in Anesthetized Patients

METHODS: We studied 20 anesthetized patients with healthy lungs undergoing faciomaxillary surgery. After a stepwise increase of PEEP/inspiratory pressures (0/10, 5/15, 10/20, 15/25 cm H_2O, each level lasting for 20 min) using a pressure-controlled ventilation mode, a recruitment maneuver (at 20/45 cm H_2O for a maximum of 20 min) was performed, followed by a stepwise pressure reduction (15/25, 10/20, 5/15, 0/10 cm H_2O, with 20 min at each level). At each pressure level, FRC, compliance, Pao_2, and dead space fraction were measured.

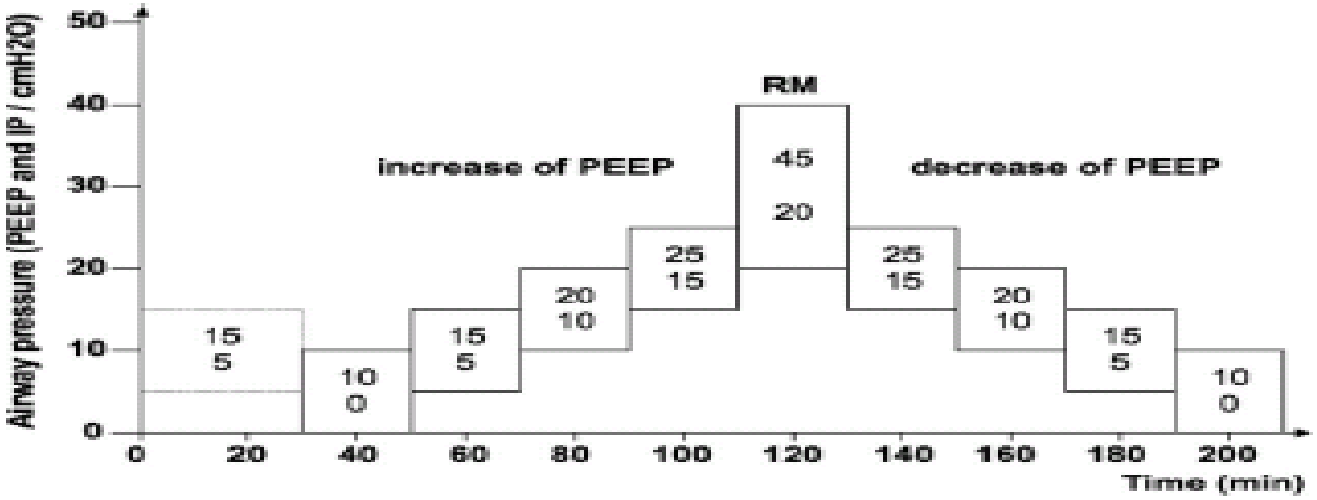
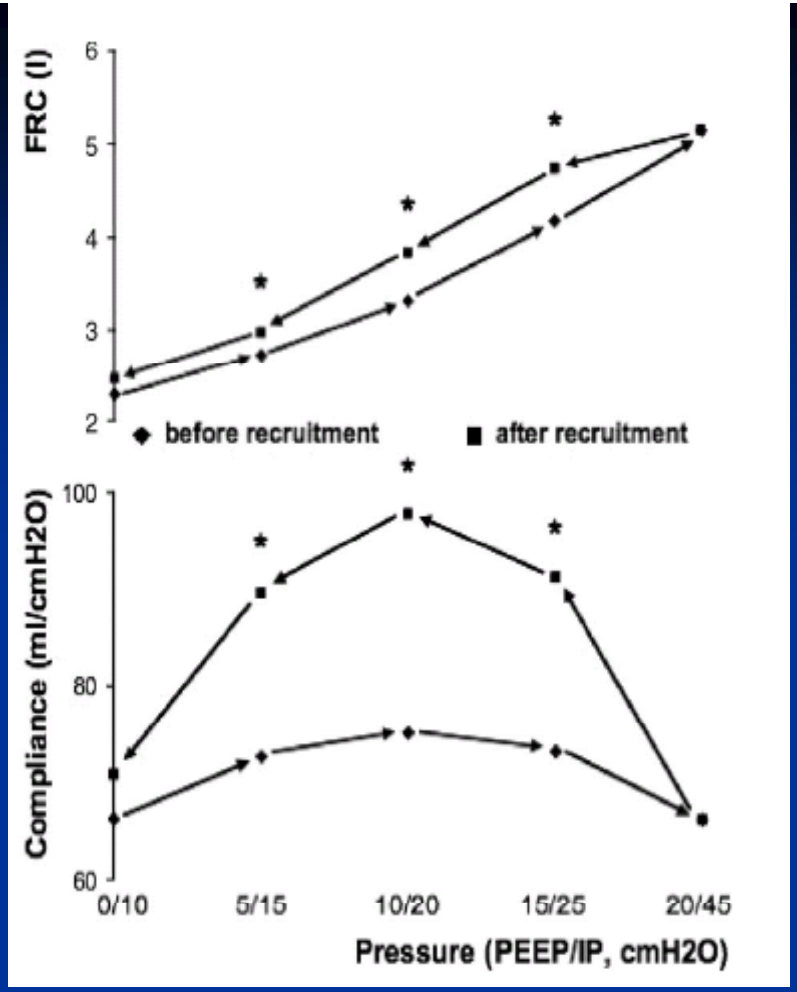
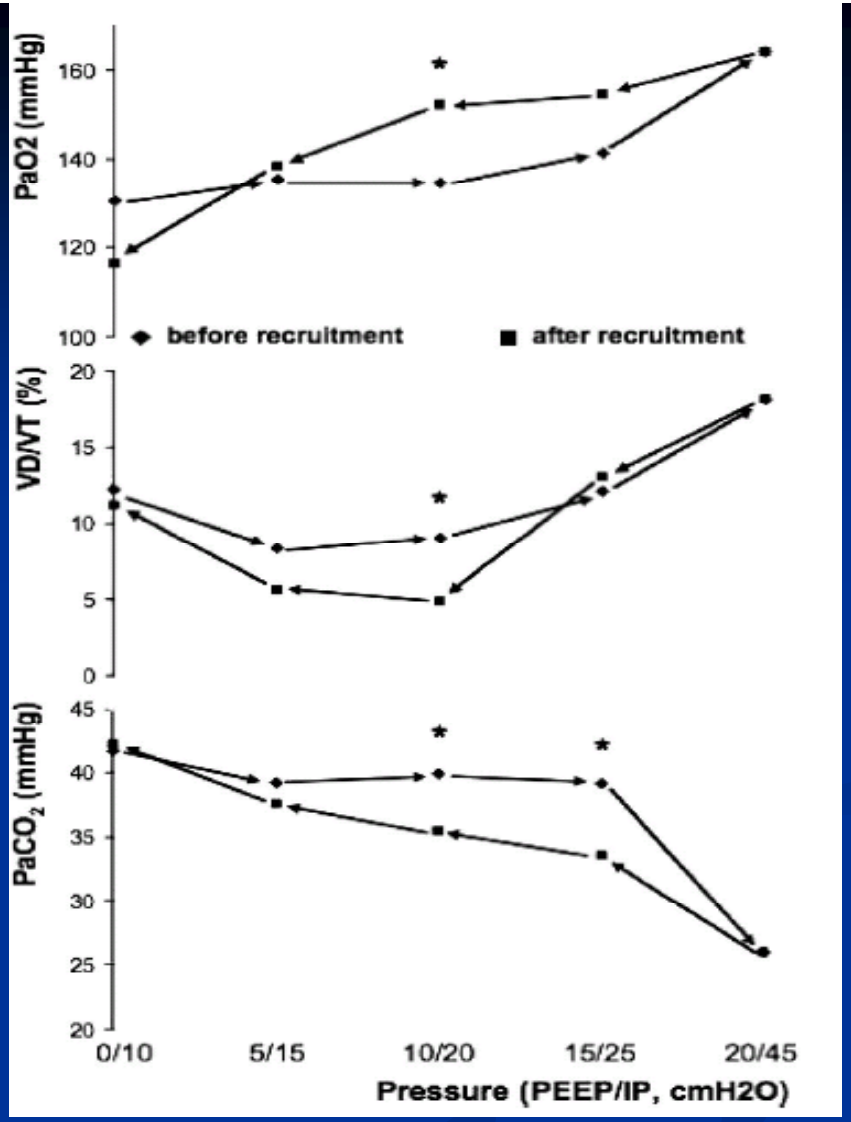


Figure 1. Schematic representation of different protocol phases. Increase of positive end-expiratory pressure (PEEP), recruitment maneuver (RM), and decrease of PEEP (IP = inspiratory pressure).





CONCLUSIONS: All variables showed the positive effects of PEEP in conjunction with a recruitment maneuver. Optimal PEEP was 10 cm H_2O because at this pressure level the highest compliance value in conjunction with the lowest dead space fraction indicated a maximum amount of effectively expanded alveoli. FRC and Pao_2 were insensitive to alveolar over-distension.

(Anesth Analg 2008;106:175–81)

肺复张改善重症病人插管后出现的低氧血症：一项随机对照研究

Constantin *et al. Critical Care* 2010, **14**:R76
http://ccforum.com/content/14/2/R76

RESEARCH Open Access

A recruitment maneuver increases oxygenation after intubation of hypoxemic intensive care unit patients: a randomized controlled study

Jean-Michel Constantin*[1], Emmanuel Futier[1], Anne-Laure Cherprenet[1], Gérald Chanques[2], Renaud Guerin[1], Sophie Cayot-Constantin[1], Mathieu Jabaudon[1], Sebastien Perbet[1], Christian Chartier[1], Boris Jung[2], Dominique Guelon[3], Samir Jaber[2] and Jean-Etienne Bazin[1]

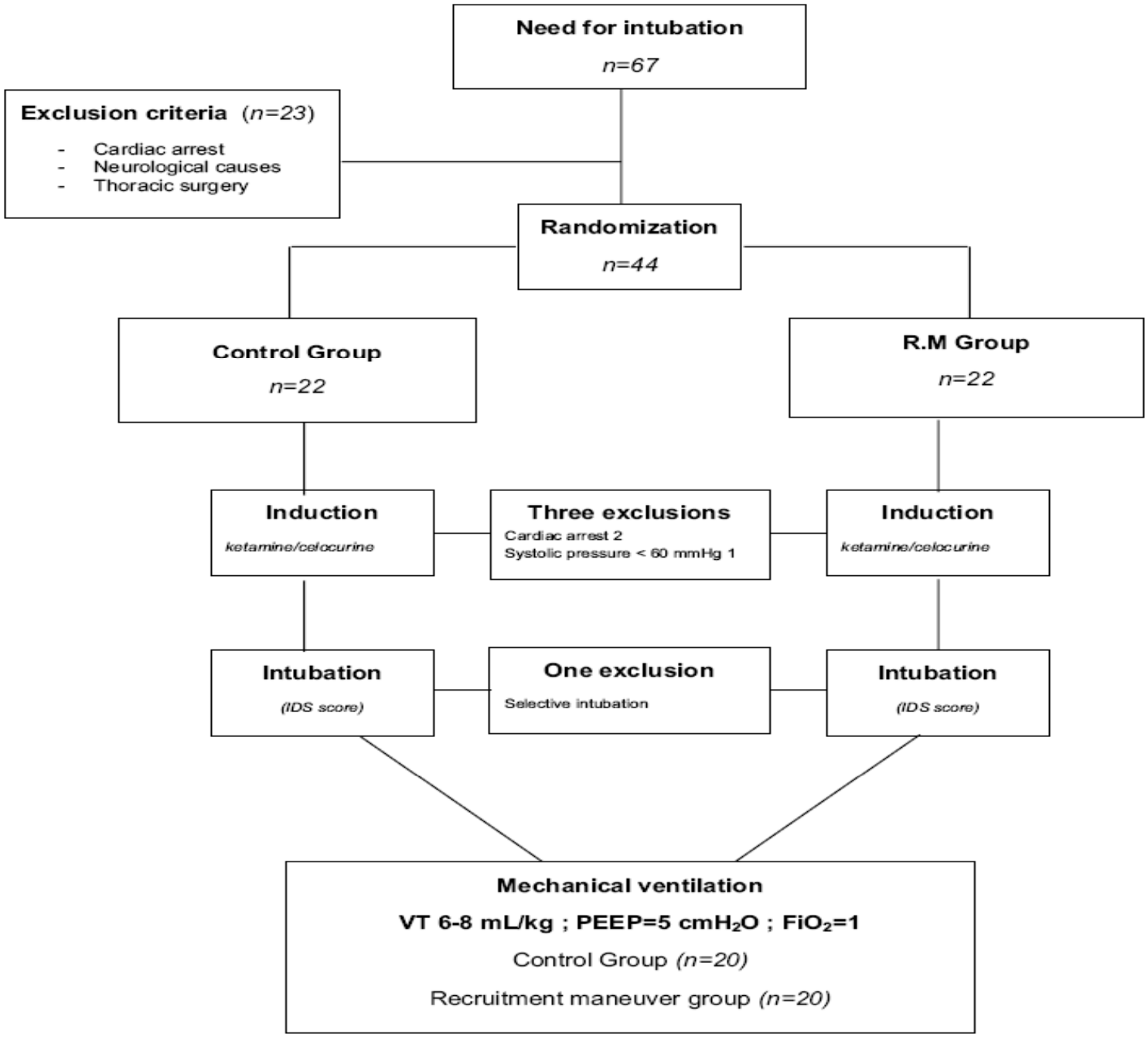

Need for intubation
n=67
Exclusion criteria (n=23)
- Cardiac arrest
- Neurological causes
- Thoracic surgery
Randomization
n=44
Control Group
n=22
R.M Group
n=22
Induction
ketamine/celocurine
Three exclusions
Cardiac arrest 2
Systolic pressure < 60 mmHg 1
Induction
ketamine/celocurine
Intubation
(IDS score)
One exclusion
Selective intubation
Intubation
(IDS score)
Mechanical ventilation
VT 6-8 mL/kg ; PEEP=5 cmH2O ; FiO2=1
Control Group (n=20)
Recruitment maneuver group (n=20)

Table 1: Clinical characteristics of patients at inclusion

	Control group (n = 20)	RM group (n = 20)	*P*
Age (years)	67 ± 8	62 (9)	0.19
Gender (F/M)	7/13	5/15	0.73
Height (cm)	167 ± 6	172 ± 8	0.09
Weight (kg)	72 ± 18	74 ± 10	0.66
SAPS II score [16]	48 ± 18	44 ± 23	0.49
Knaus class A/B/C/D (no.) [18]	2/8/6/4	3/9/6/2	0.8
McCabe score 1/2/3 (no.) [17]	5/10/5	4/10/6	0.9
Diagnosis			
Pneumonia (no.)	10	11	
Extra pulmonary ALI (no.)	6	7	
Other (no.)	4	2	

ALI: acute lung injury; F: female; M: male; RM: recruitment manoeuvre; SAPS II: simple acute physiologic score II.
Chi-squared for overall diagnoses: $P = 0.673$.

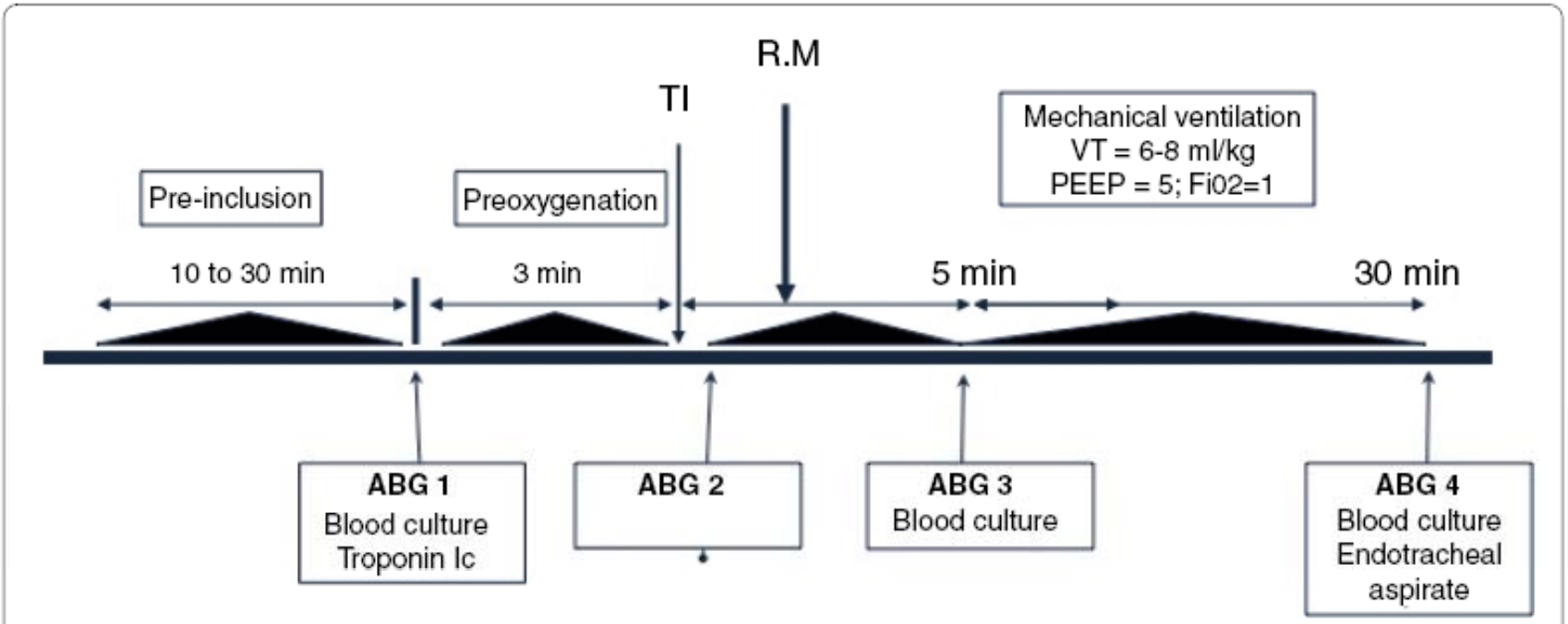


Figure 1 Design of the study. During the inclusion period, patients were randomized to a control or recruitment manoeuvre (RM) group. Clinical parameters were recorded and arterial blood gases (ABG 1) sampled at inclusion. Preoxygenation was performed for a three-minute period. Immediately after tracheal intubation (TI), a second set of ABG measurements were taken (ABG 2). Less than two minutes after intubation, an RM was performed (RM group); no RM was administered to patients in the control group. Protective mechanical ventilation with positive end-expiration pressure (PEEP) at 5 cmH_2O was commenced immediately after intubation. Five and thirty minutes after intubation, ABG measurements were again performed (ABG 3 and ABG 4). At inclusion, and 5 and 30 minutes after intubation, blood samples were taken for culture. Troponin Ic levels were sampled at inclusion and six hours after intubation. Thirty minutes after intubation, endotracheal aspiration was performed on all patients. VT: tidal volume.

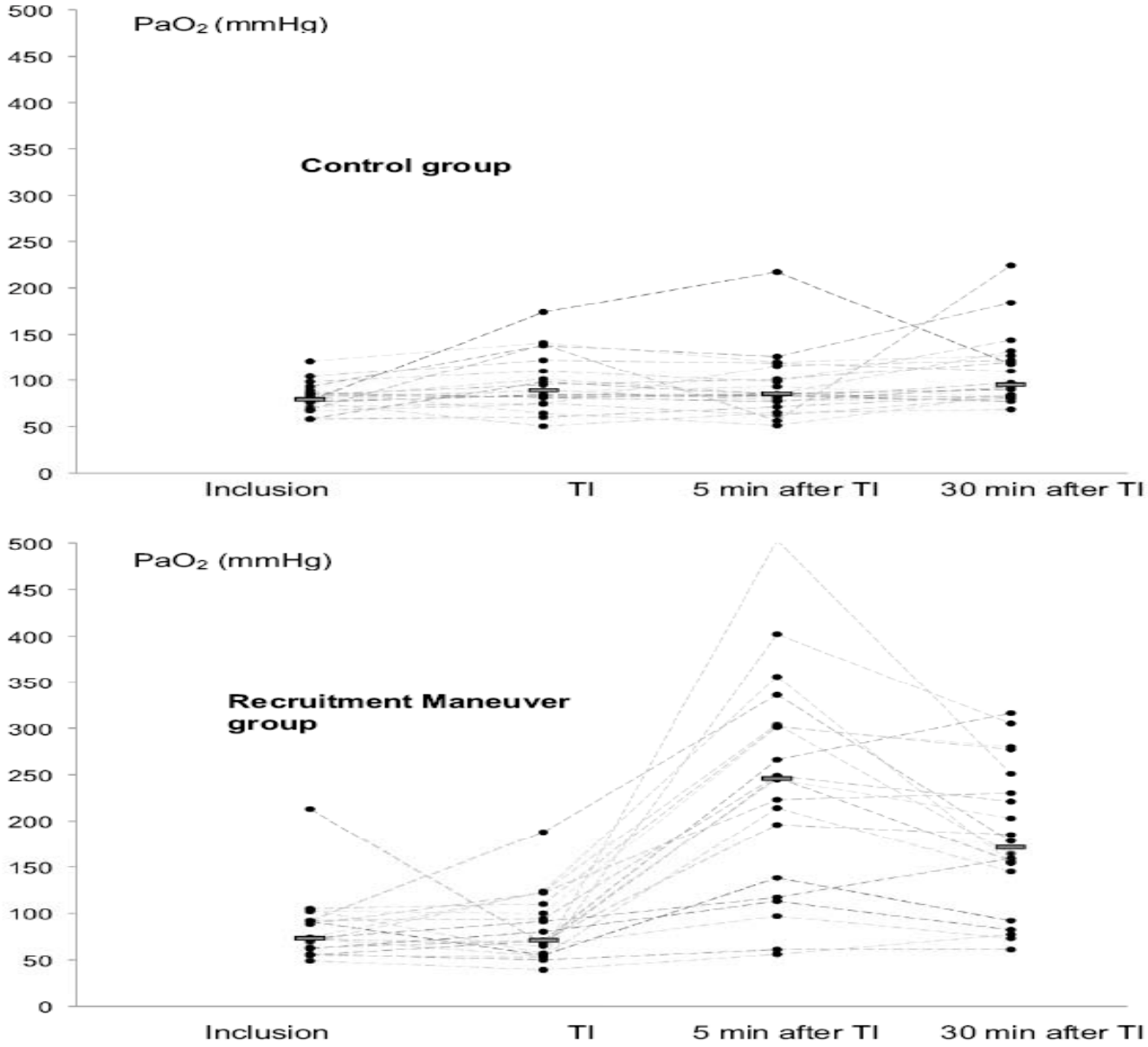


Figure 3 Individual PaO_2 values at different study times. Individual partial pressure of arterial oxygen (PaO_2) at inclusion, immediately after intubation (TI), 5 minutes after intubation, and 30 minutes after intubation of patients in the control group (top), and RM group (bottom). A full circle represents an individual value. Bars represent median values. One patient had a PaO_2 of 504 mmHg after RM. These data are not shown in the Figure.

Table 4: Bacteriological data obtained from the 19 patients with positive samples

	Blood culture			Endotracheal aspirate
	Before intubation	5 minutes after intubation	30 minutes after intubation	30 minutes after intubation
Control group (n = 10)				
	---	MRSA	MRSA	MRSA
	---	P aeruginosa	*P aeruginosa*	*P aeruginosa*
	---	---	*P aeruginosa*	*P aeruginosa*
	---	*E coli*	*E coli*	*E coli*
	---	*K pneumoniae*	*K pneumoniae*	*K pneumoniae*
	K oxytoca	*K oxytoca*	---	---
	---	*C albicans*	*C albicans*	*C albicans*
	---	---	---	MRSA
	---	---	---	*P aeruginosa*
	---	---	---	*K pneumoniae*
RM group (n = 13)				
	---	*K pneumoniae*	---	*K pneumoniae*
	---	---	*M moranii*	*M moranii*
	---	*E cloacae*	*E cloacae*	*E cloacae*
	E coli	*E coli*	*E coli*	---
	---	Lactobacillus	---	Lactobacillus
	---	*C albicans*	---	*C albicans*
	---	---	MRSA	MRSA
	---	*P aeruginosa*	---	*P aeruginosa*
	---	---	---	*E fecium*
	---	---	---	*K pneumoniae*
	---	---	---	*P aeruginosa*
	---		---	*P aeruginosa*
	---	---	---	MRSA

C albicans:Candida albicans;E cloacae: Enterobacter cloacae; E coli: Escherichia coli; E fecium: Enterococcus fecium; K oxytoca: Klebsiella oxytoca; K pneumoniae: Klebsiella pneumoniae; M moranii: Morganella moranii; MRSA: methicillin-resistant *Staphylococcus aureus; P aeruginosa: Pseudomonas aeruginosa.*

Conclusions

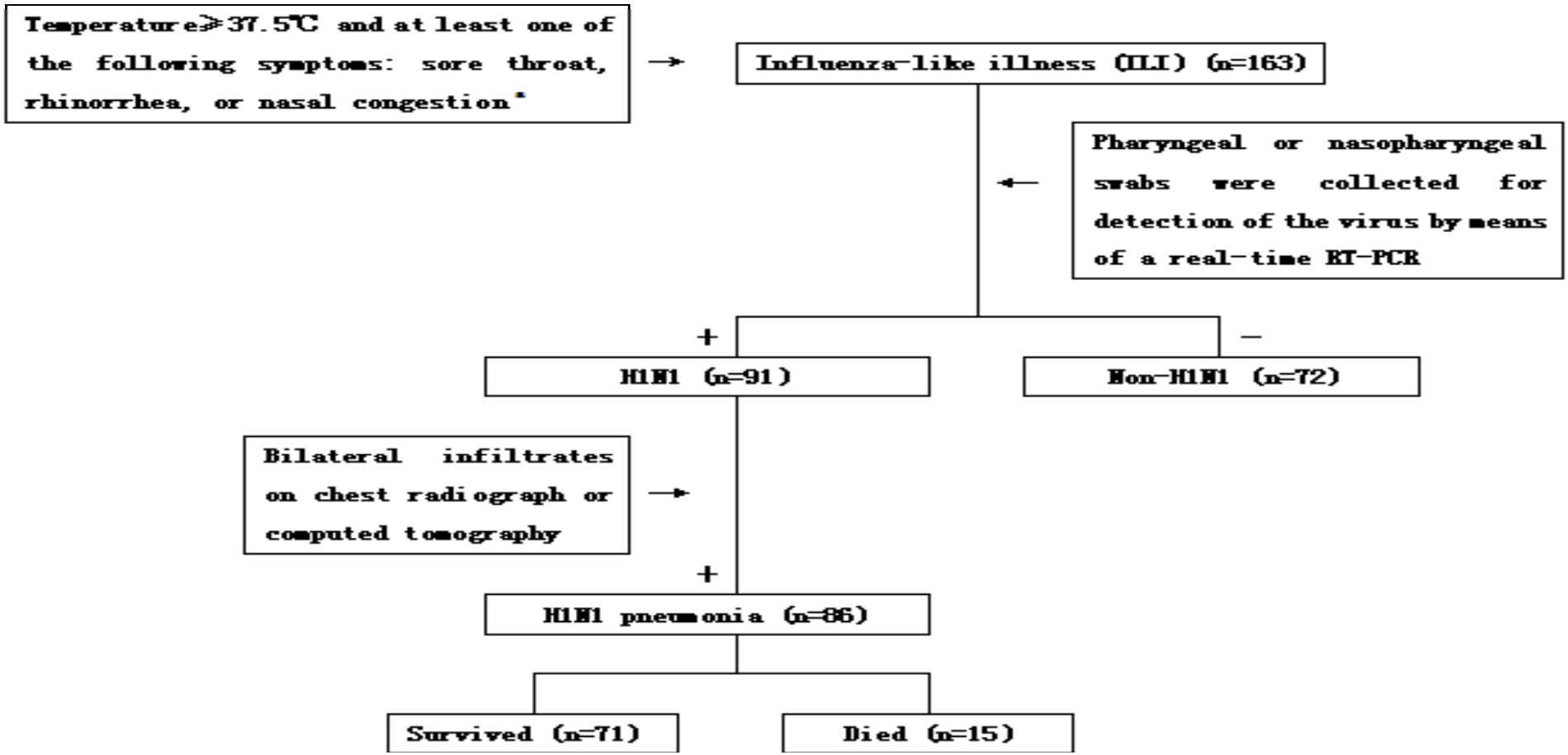
Lung collapse following tracheal intubation and anesthesia in hypoxemic patients is often a life-threatening condition. The use of RM appears safe and efficient, limiting the depth of short-term hypoxemia in our study population. Notwithstanding the effect of RM on PaO_2 levels following intubation, the RM did not decrease desaturation during intubation. Preoxygenation with intubation followed by RM is an attractive treatment strategy that merits further study.

Key messages

- RM immediately after intubation are efficient to reduce short-term hypoxemia and appeared safe.
- RM could be used after intubation of hypoxemic patients to limit the depth and duration of hypoxemia.

重症病人插管后行肺复张可有效地减轻其一过性低氧血症，建议低氧血症病人插管后行肺复张可减少其低氧血症的程度和时间。

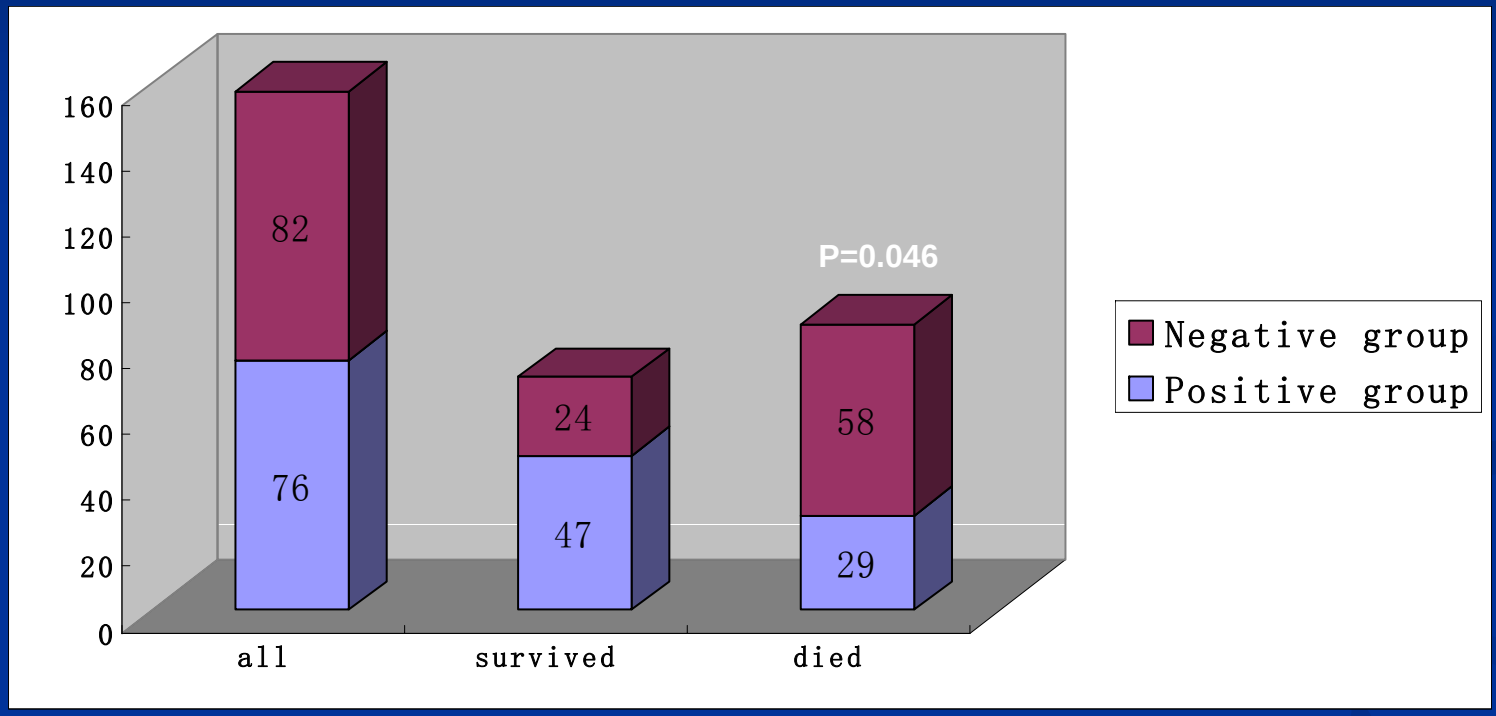
Introduction： 2009年我院救治H1N1肺炎经验



Time from onset of symptoms to admission: Median 3.5days (Range <1～9) .Most patients not first visit

a: H1N1 influenza diagnosis and treatment program (2009 Third Edition) , Ministry of Health of P.R of China.

Response to lung recruitment maneuvers (n=12)



- Positive group：SpO2↑≥ 5% within 15min after RM
- Negative group：SpO2↑＜ 5% within 15min after RM
- recruitment maneuvers: ↑PEEP to 30cmH_2O for 40s, 4～6 time/24h

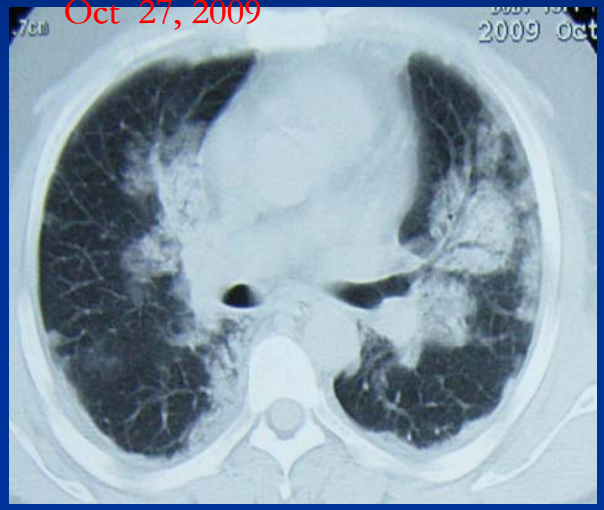
Impact factors on the effect of lung recruitment maneuvers

- PEEP: baseline peep 8～22 cmH_2O
- Symptom onset to mechanical ventilation : 4 ～11days
- Consolidation

Case 3

Male,38yr,no underlying diseases, MV, died

Oct 27, 2009



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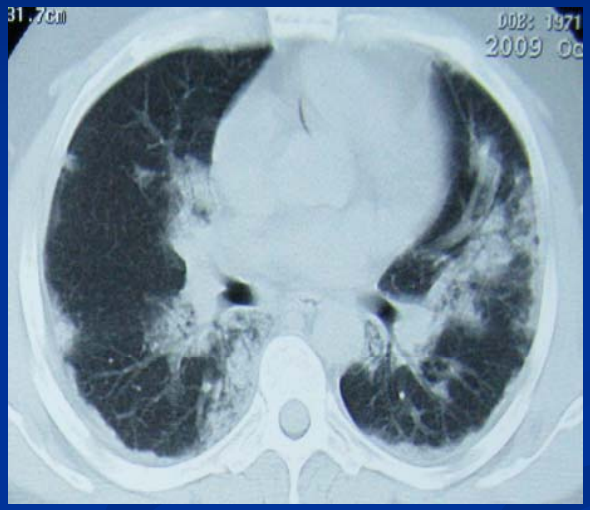

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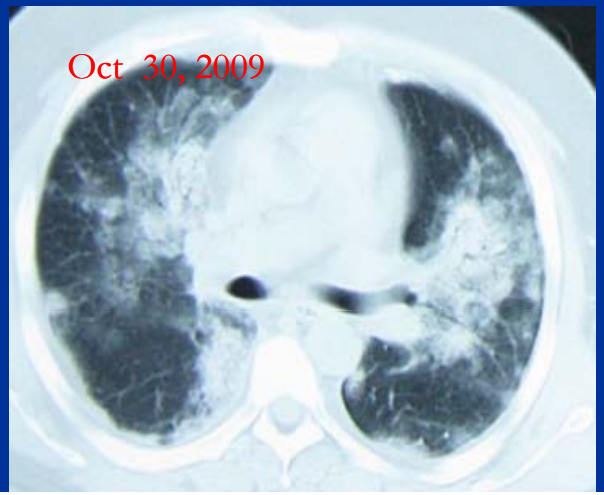

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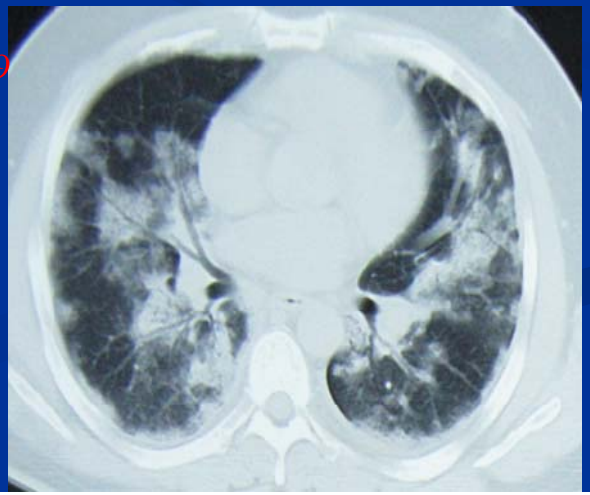
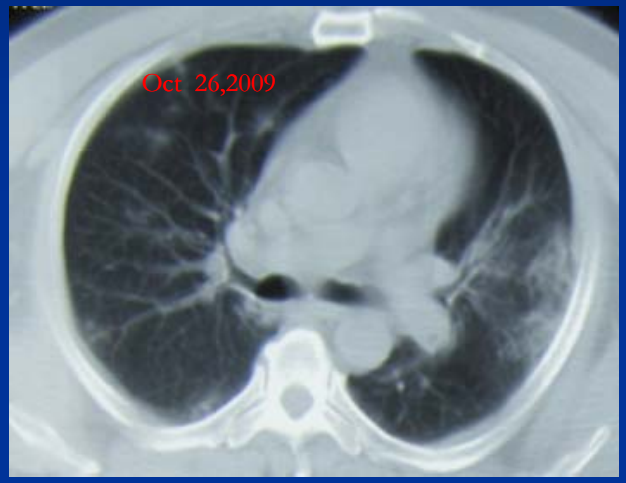
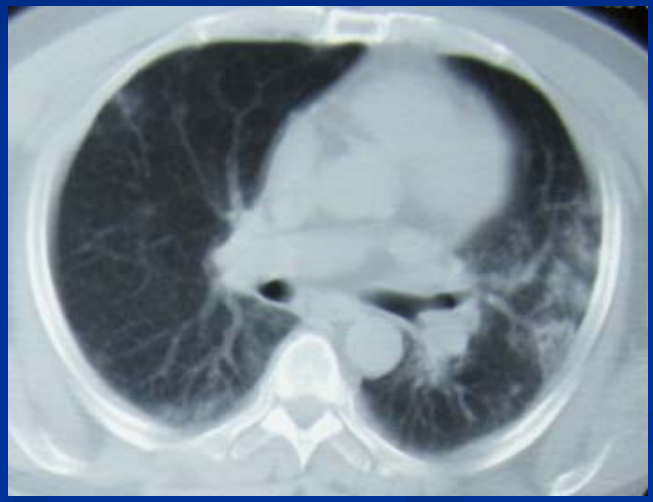


Case 2

Male,47yr,no underlying diseases, MV, died





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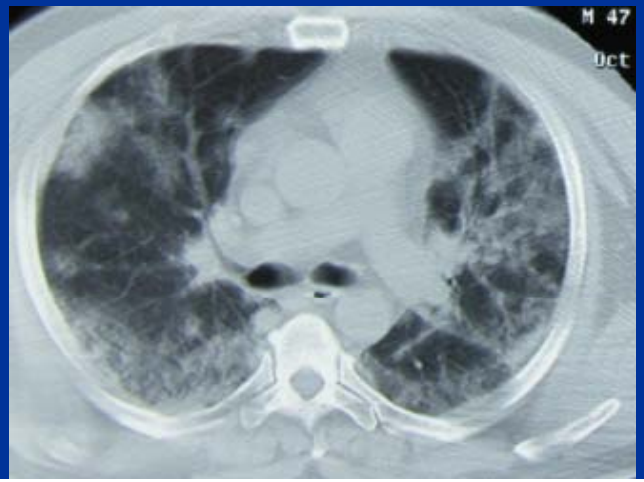

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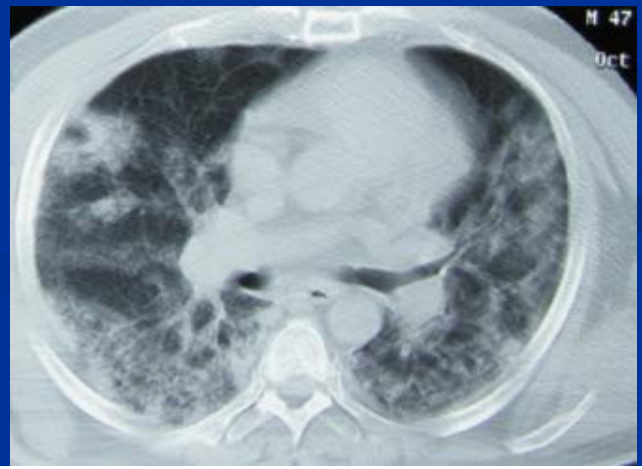


应用肺影像评估肺复张对ARDS的疗效

Lung morphology predicts response to recruitment maneuver in patients with acute respiratory distress syndrome

Jean-Michel Constantin, MD, PhD; Salvatore Grasso, MD, PhD; Gerald Chanques, MD; Sophie Aufort, MD; Emmanuel Futier, MD; Mustapha Sebbane, MD; Boris Jung, MD; Benoit Gallix;

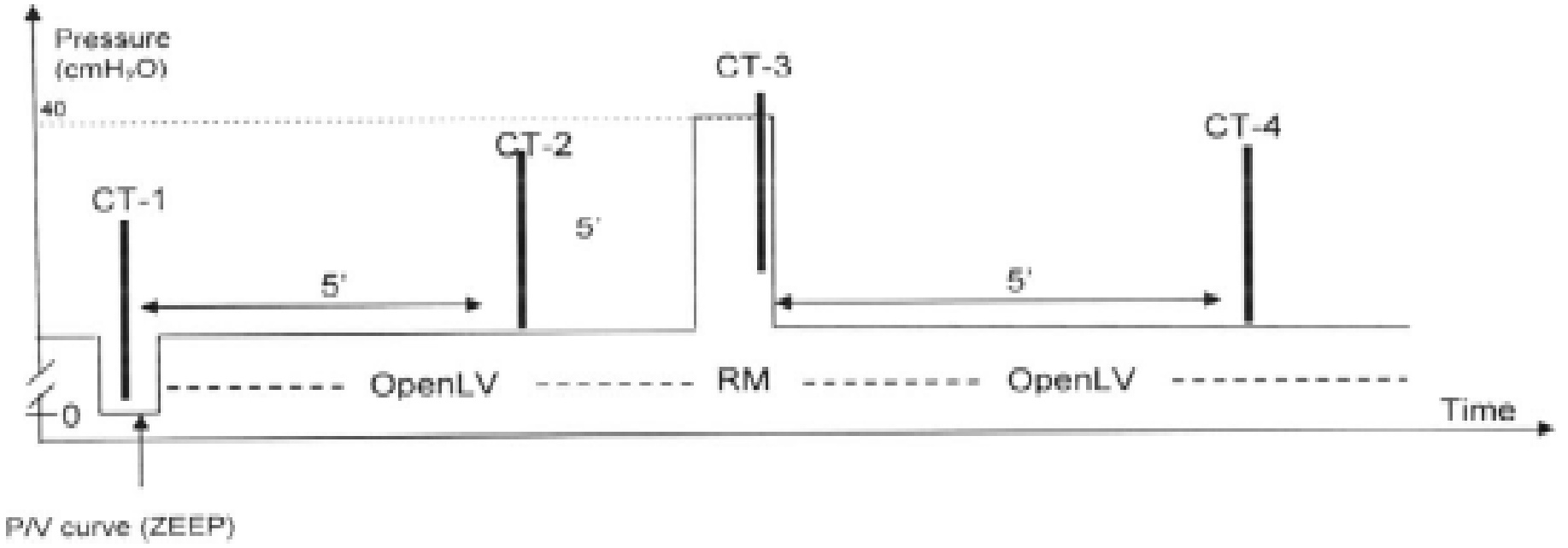
Table 1. Clinical characteristics of the patients

	Cause of Acute Respiratory Distress Syndrome	Type of Acute Respiratory Distress Syndrome	Lung Morphology	Age, yr	Gender	Lower Inflection Point of the Quasi-Static Pressure–Volume Curve, cm H_2O	Ideal Body Weight, kg	Onset, hr	Simple Acute Physiologic Score	Outcome
1	Pancreatitis	EP	NF	42	M	6	66	6	39	S
2	Aspiration	P	NF	78	M	12	63	12	32	S
3	Pneumonia	P	FO	71	M	13	70	12	51	S
4	Peritonitis	EP	FO	84	M	—	77	48	44	D
5	Peritonitis	EP	FO	78	F	6	75	6	42	D
6	Peritonitis	EP	NF	73	F	8	66	12	39	S
7	Pneumonia	P	FO	77	M	9	61	24	56	S
8	Pneumonia	P	NF	60	F	13	60	24	45	D
9	Pneumonia	P	NF	55	F	13	66	6	37	S
10	Aspiration	P	FO	65	M	14	60	6	77	S
11	Pneumonia	P	NF	19	M	11	72	12	22	S
12	Pneumonia	P	NF	53	F	8	50	24	51	S
13	Pneumonia	P	FO	62	M	9	64	24	68	S
14	Pneumonia	P	NF	54	F	6	50	24	32	S
15	Peritonitis	EP	NF	58	M	8	67	24	42	S
16	Peritonitis	EP	NF	67	M	10	66	24	26	D
17	Peritonitis	EP	FO	75	M	—	82	24	61	S
18	Pneumonia	P	FO	65	F	10	67	36	42	S
19	Aspiration	P	FO	79	F	13	57	24	60	D
Mean ± SD				65 ± 15		9.7 ± 3	65 ± 8	20 ± 10	45 ± 14	

P, pulmonary; EP, extrapulmonary; FO, focal; NF, nonfocal; M, male; F, female; D, deceased; S, survivor.

Patients 4 and 17 had no identifiable lower inflection point on the pressure–volume curve. Onset indicates delay between the diagnosis of acute respiratory distress syndrome and computed tomography scan.

肺复张流程



OpenLV: 2cmH2O above lower inflection point

RM: CPAP 40cmH2O for 40 s

肺复张的影像变化

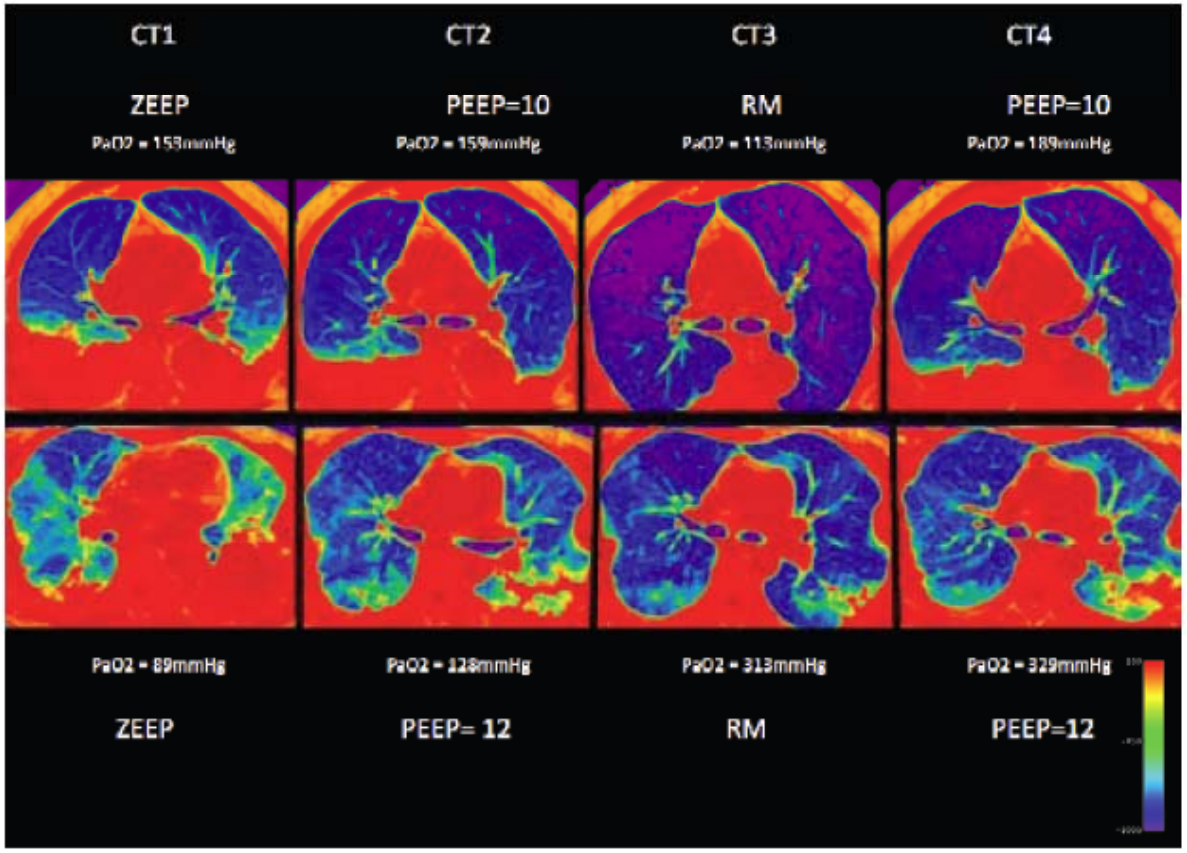
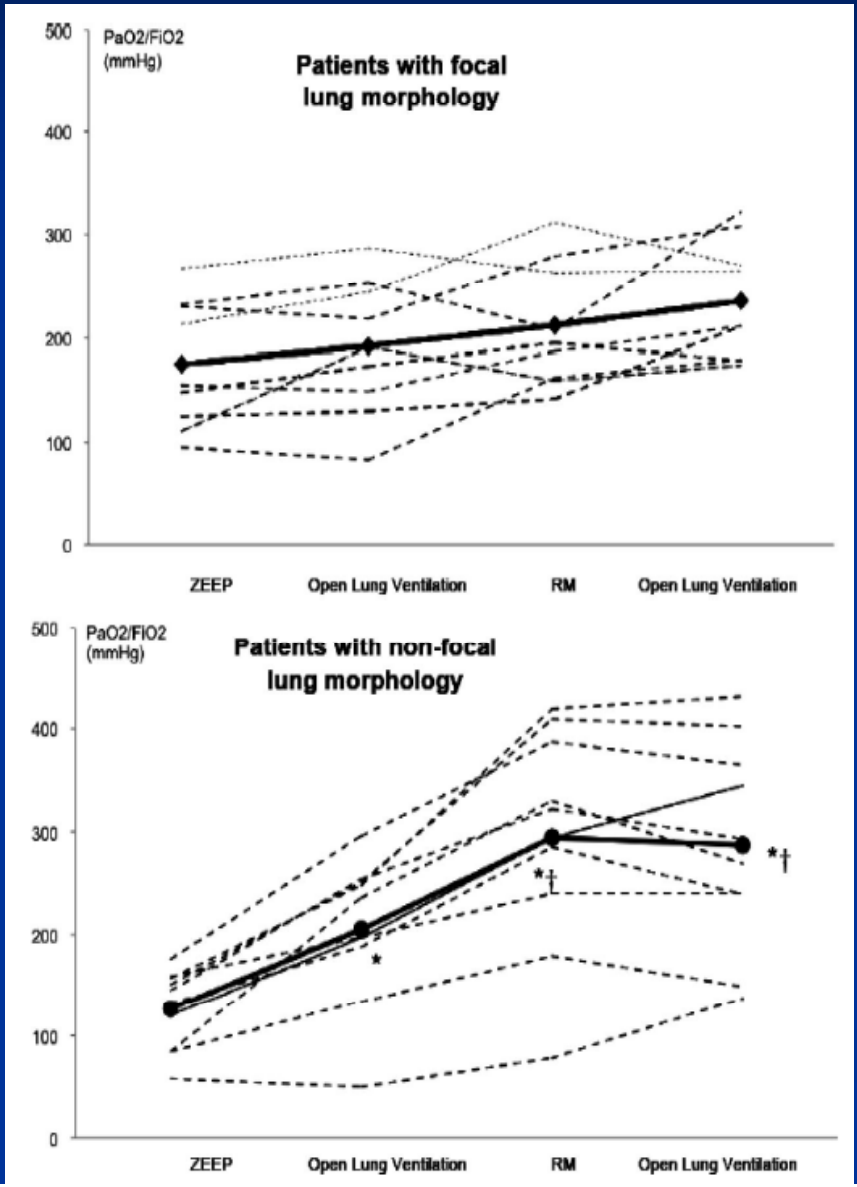
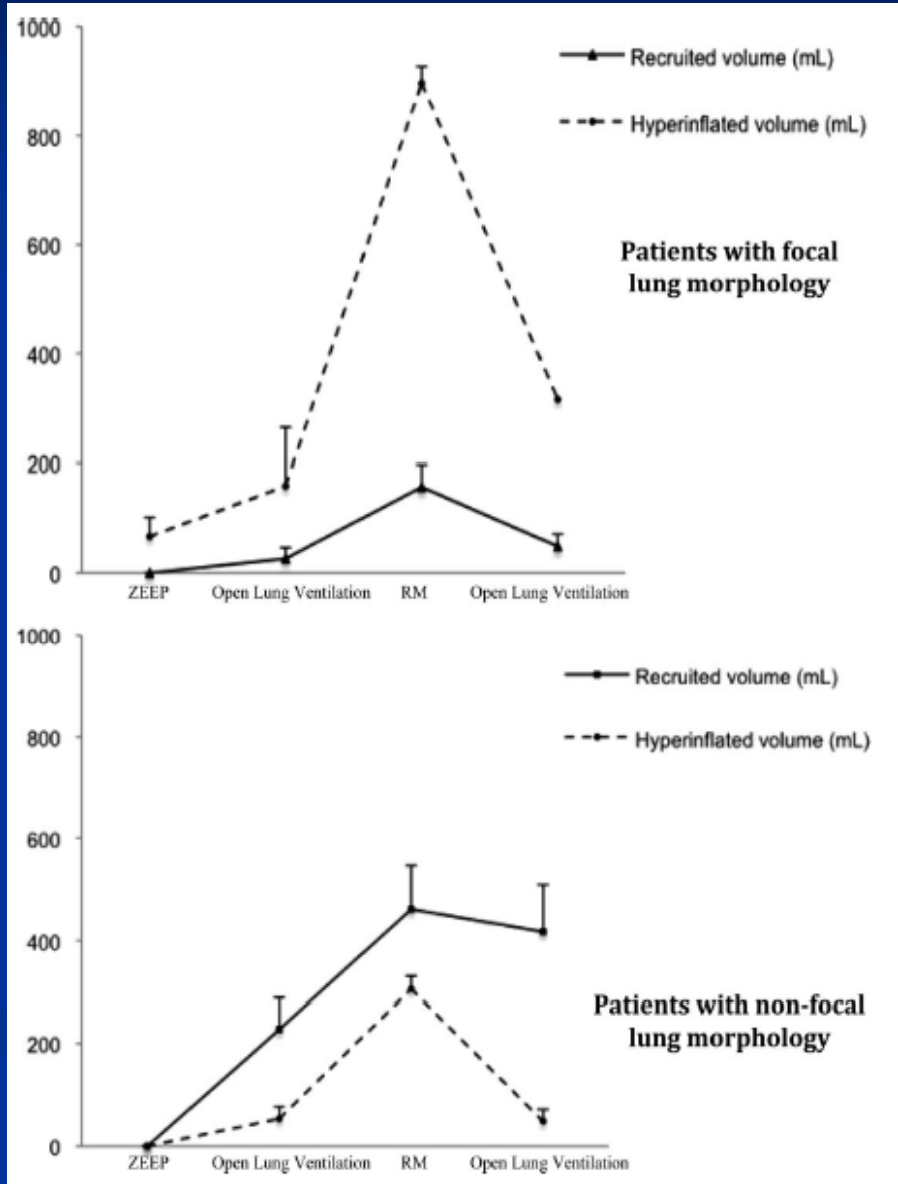


Figure 5. Two representative patients with focal (*upper*) and nonfocal (*lower*) lung morphology. Computed tomography sections are represented with color-encoding aimed at evidencing different degrees of lung aeration. In the patient with focal lung morphology, recruitment maneuver (RM)-induced increase in lung volume is essentially made of hyperinflation (*purple*) associated to full recruitment of lower lobes (*red* and *green*, characterizing nonaerated and poorly aerated lung, are not visible and are replaced by *dark blue* and *purple*). Hyperinflation is already present during the first period of open-lung ventilation and is much greater after RM. Simultaneously there is a slight increase in PaO_2. In the patient with nonfocal lung morphology, RM-induced increase in lung volume is essentially made of recruitment (*red* and *green* are replaced by *dark* and *light blue*, characterizing normally aerated lung regions) associated to moderate hyperinflation of nondependent parts of the lungs. Hyperinflation is not observed during open-lung ventilation before or after RM. Simultaneously, there is a marked increase in PaO_2 from 89 to 329 mm Hg. *ZEEP*, zero end-expiratory pressure; *PEEP*, positive end-expiratory pressure.

局灶性和非局灶性肺影像病变对肺复张的反应





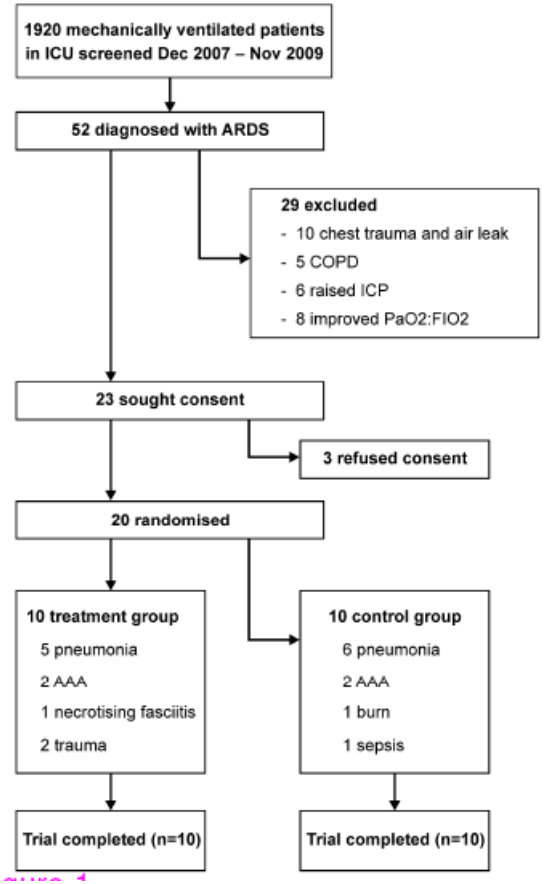
Conclusion: Lung morphology at zero end-expiratory pressure predicts the response to recruitment maneuvers. Patients with focal lung morphology are at risk for significant hyperinflation during the recruitment maneuvers, and lung recruitment is rather limited. (Crit Care Med 2010; 38:1108–1117)

肺影像结构可评估肺复张疗效，肺“局部病灶”肺复张可导致过度膨胀是肺复张的相对禁忌。

阶梯式RM+PEEP滴定及目标低气道压对ARDS患者效果的评价

A randomised controlled trial of an open lung strategy with staircase recruitment, titrated PEEP and targeted low airway pressures in patients with acute respiratory distress syndrome

Critical Care 2011, **15**:R133 doi:10.1186/cc10249



PCV Pplat <30cmH2O Vt: 6ml/Kg

SRM: PEEP 40cmH2O+PCV 15cmH2O for 2min

20cmH2O→30cmH2O→40cmH2O every 2 min

25cmH2O→22.5cmH2O→20cmH2O→17.5cmH2O→15cmH2O every 3 min→ Derecuitment PEEP +2.5cmH2O

Once a day

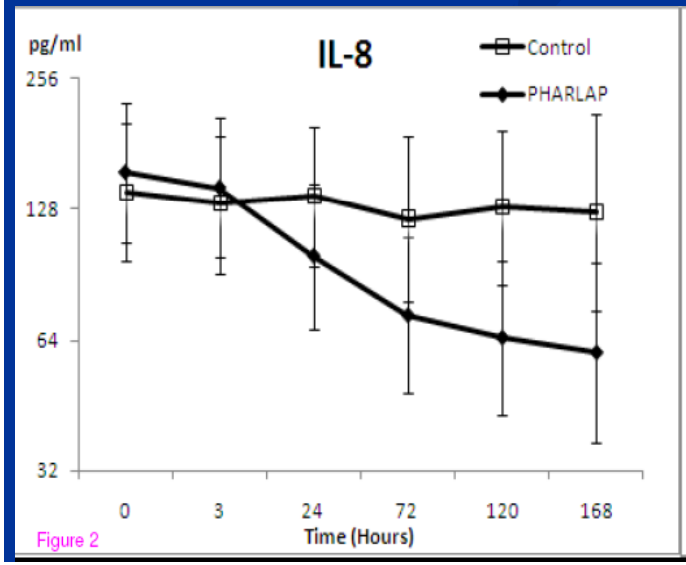
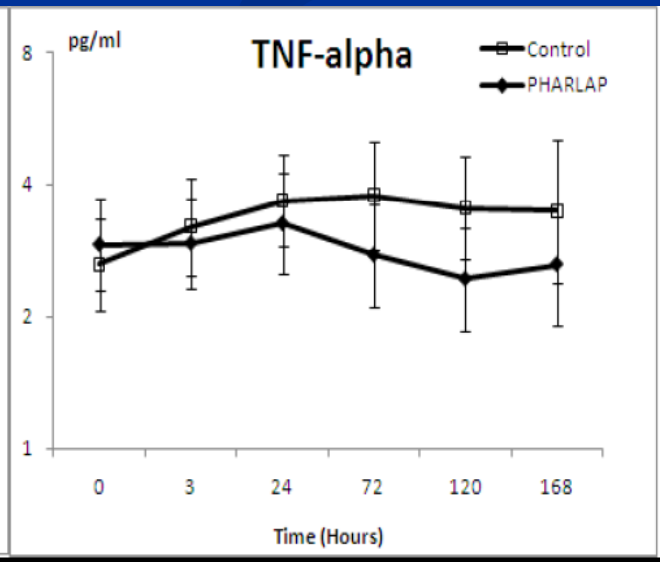
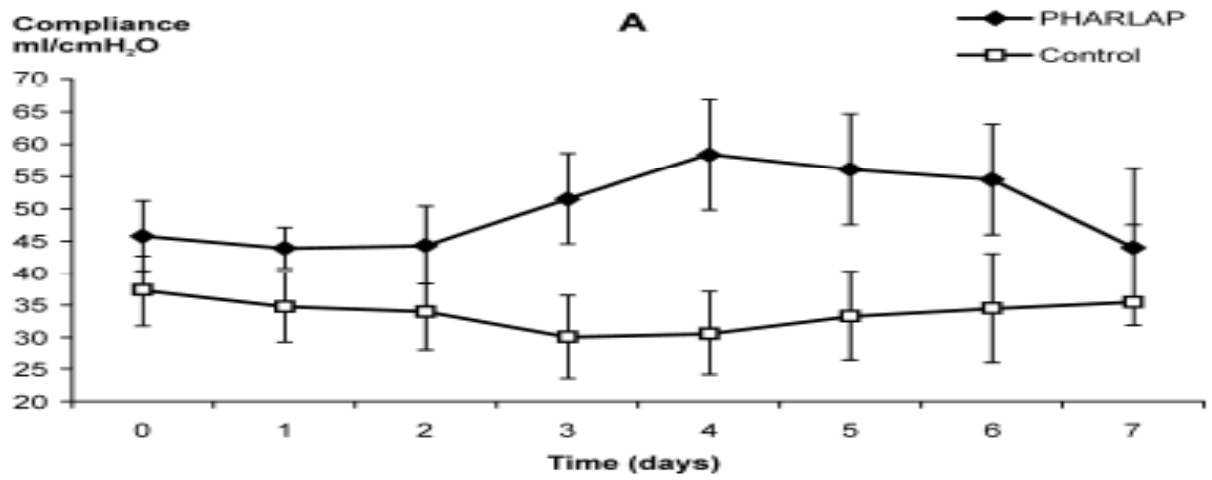
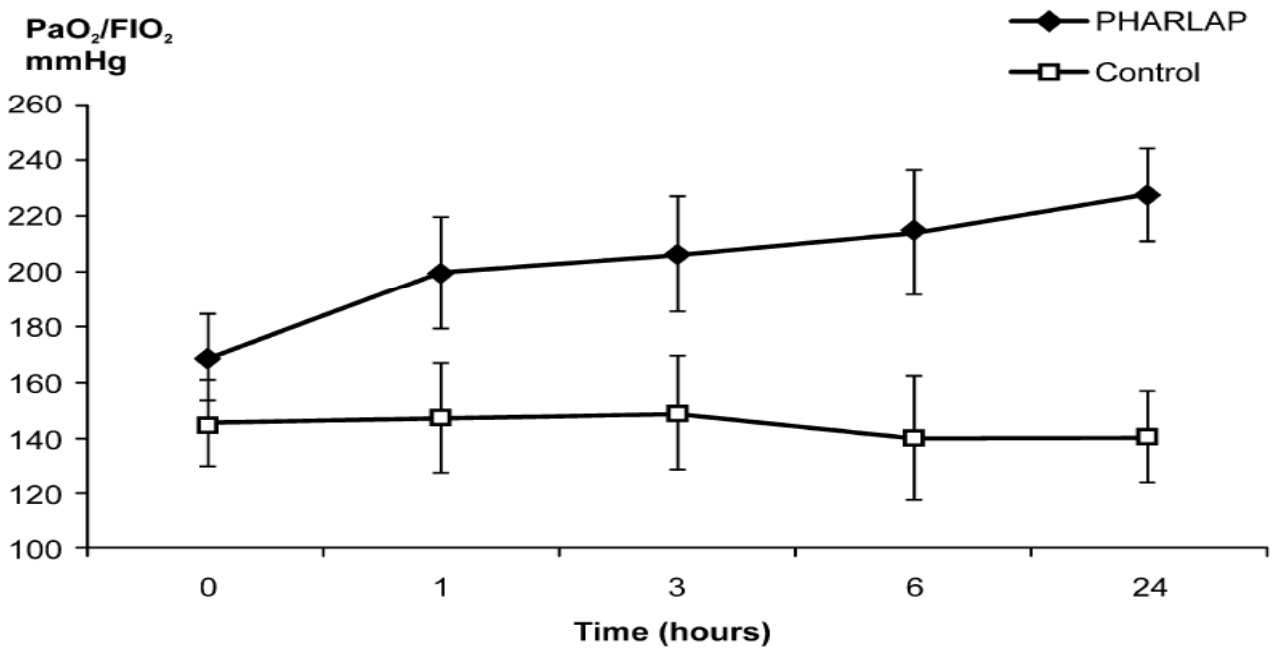


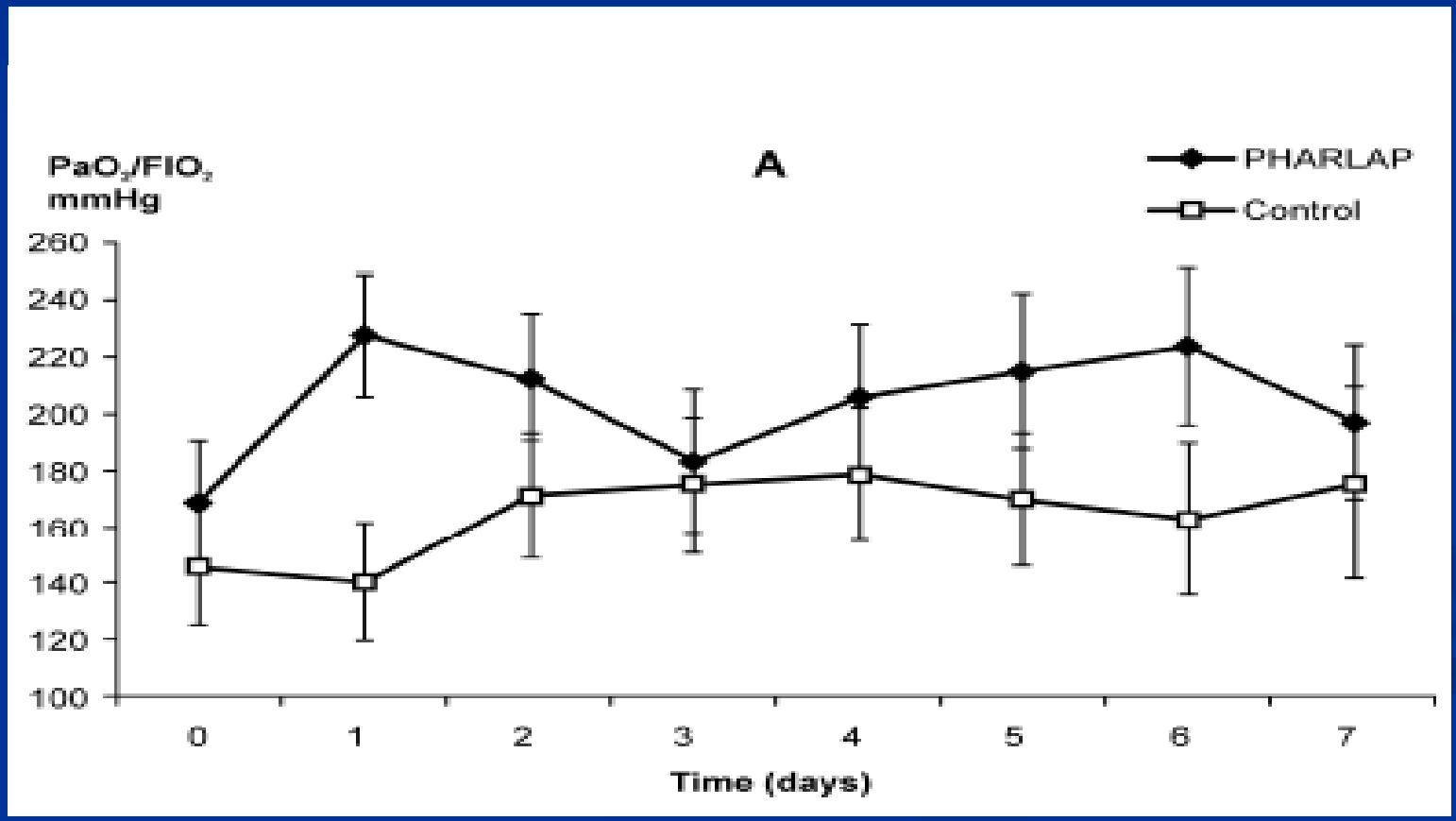
Figure 2





PHARLAP :Permissive hypercapnia, Alveolar recruitment, Low airway pressure




A
PaO2/FIO2
mmHg
PHARLAP
Control
260
240
220
200
180
160
140
120
100
0
1
2
3
4
5
6
7
Time (days)

Key messages:

- An open lung strategy including staircase recruitment and PEEP titration improved plasma cytokines, static lung compliance and oxygenation over 7 days
- An open lung strategy including staircase recruitment and PEEP titration was safe
- Open lung ventilation was associated with a trend for reduced duration of ventilation that requires investigation in a larger trial
- Open lung ventilation was associated with less use of rescue therapies

肺开放策略包括RM和PEEP滴定可改善血浆细胞因子，及肺顺应性和氧合。

目前对实施RM的共识

（1）在ARDS早期肺水肿明显，RM效果较好。

（2）肺外因素所致ALI的RM效果优于肺内因素ALI。

（3）胸壁顺应性较差（如肥胖、胸廓畸形、腹胀等）RM的疗效下降。

（4）复张后吸氧浓度应尽力降低至可以维持基本氧合最低水平，防止复张的肺泡因氧气吸收过快再次萎陷。

（5）常用的RM持续时间为15～30s，压力为25～40cmH_2O。

（6）RM后，复张肺泡维持时间与PEEP水平有关。

（7）连续使用RM氧合不再提高，应减少RM避免气压伤发生。

谢谢！