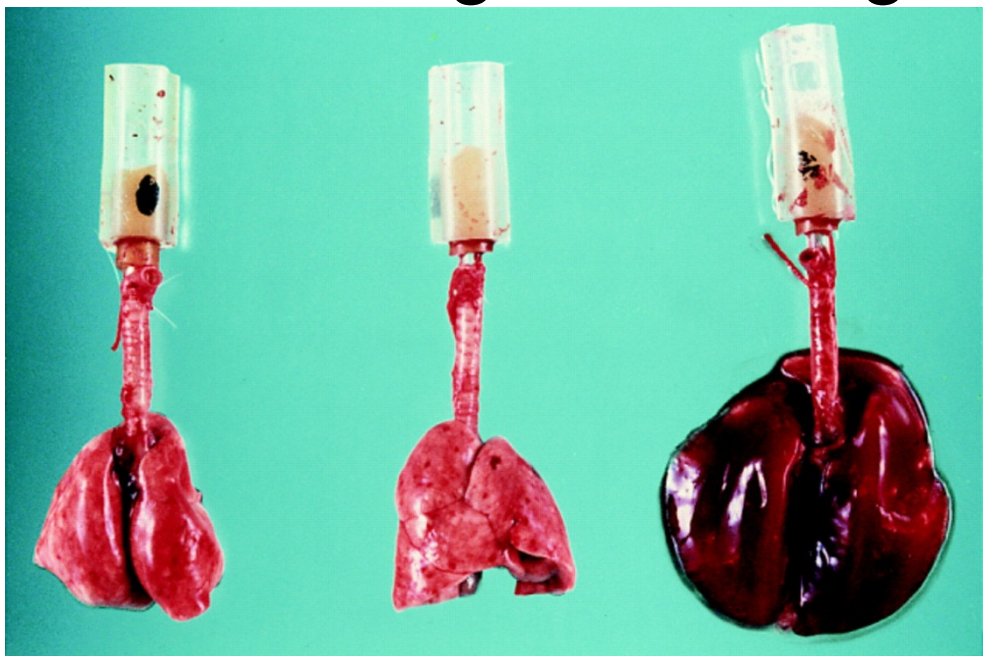
Beatmung während einer Allgemeinanästhesie
- Tidalvolumen -

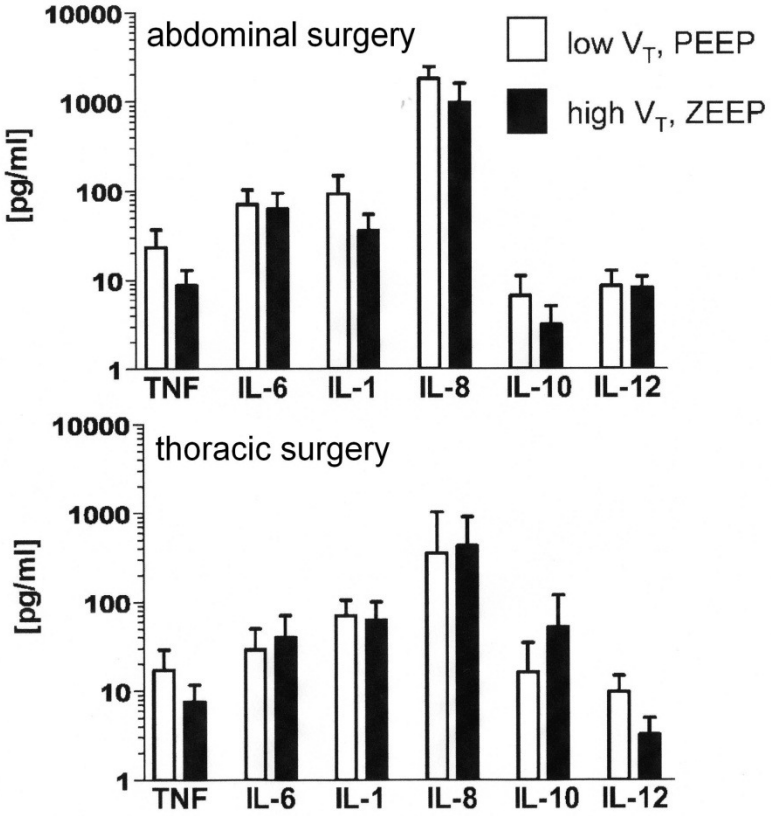
State of the Art

Große Tidalvolumina können im Experiment gesunde Lungen schädigen.

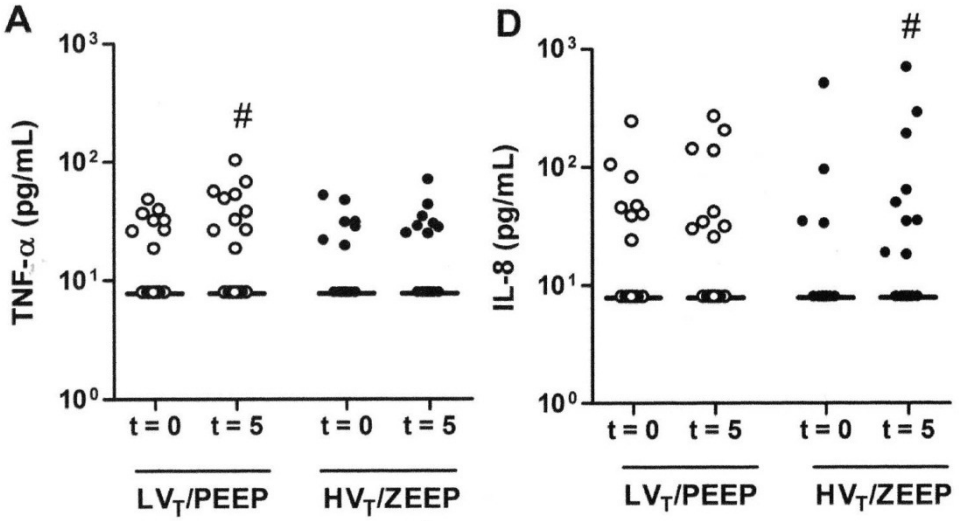


Dreyfuss D et al. Am J Respir Crit Care Med 1998;157:294-323

Intraoperatives V_T: Inflammation? Uneinheitliche Ergebnisse



Wrigge H et al.
Anesth Analg 2004;98:775-81



Wolthuis EK et al.
Anesthesiology 2008;108:46-54

Intraoperative ventilator settings and acute lung injury after elective surgery: a nested case control study.

Fernandéz-Perez ER et al. Thorax 2009;64:121-7

Postoperatives ALI

Univariate analysis of preoperative predictor variables of matched ALI case controls

Variable	Controls (n = 166) (n (%))	Cases (n = 83) (n (%))	OR (95% CI)	p Value
Diabetes mellitus	30 (18.1)	30 (36.1)	2.598 (1.40–4.81)	0.002
COPD	14 (8.4)	15 (18.1)	2.689 (1.15–6.31)	0.023
Smoking	83 (50)	56 (70)	2.43 (1.31–4.51)	0.005
Alcohol	40 (24)	28 (35)	1.86 (1.00–3.50)	0.055

Univariate analysis of intraoperative predictor variables of matched ALI case controls

Variable	Controls (n = 166) (mean (SD))	Cases (n = 83) (mean (SD))	OR (95% CI)	p Value
Duration of anaesthesia (min)	324 (113)	450 (161)	1.64* (1.37–1.96)	<0.001
Non-red blood cells (ml)‡	122 (432)	683 (1161)	1.13† (1.06–1.20)	<0.001
Red blood cells (ml)	760 (941)	1723 (1939)	1.06† (1.03–1.09)	<0.001
Colloids (ml)	736 (658)	1101 (832)	1.07† (1.03–1.11)	<0.001
Fluid balance (l)	3.69 (2.21)	6.1 (3.77)	1.03† (1.02–1.05)	<0.001
Blood pressure (mm Hg)	71 (7.64)	67.9 (8)	0.93 (0.89–0.97)	0.001
$Spao_2$ (%)	98.5 (2.06)	98.6 (1.38)	0.63 (0.89–1.03)	1.212

Analyse von 4420 Patienten, > 3 h Anästhesiedauer

Postoperatives ALI

Table 6 Unadjusted univariate and adjusted multivariate analysis of intraoperative ventilator variables of matched ALI case controls

Variable	Controls (n = 166) (mean (SD))	Cases (n = 83) (mean (SD))	Unadjusted OR (95%CI)	p Value	Adjusted OR (95%CI)*	p Value
First hour						
Tidal volume/kg PBW	8.7 (1.7)	8.9 (1.6)	1.08 (0.92–1.27)	0.336	1.03 (0.84–1.26)	0.801
PEEP (cm H_2O)	1.7 (2.2)	1.4 (2.5)	0.94 (0.83–1.07)	0.344	0.89 (0.77–1.04)	0.180
Peak airway pressure (cm H_2O)	19 (4.8)	21 (5.9)	1.10 (1.04–1.15)	<0.001	1.07 (1.02–1.15)	0.045
Respiratory rate (cycles/min)	11 (1.4)	11 (1.3)	1.01 (0.82–1.24)	0.909	1.01 (0.77–1.32)	0.940
Fio_2 (%)	73 (18)	80 (17)	1.03 (1.01–1.04)	0.002	1.00 (0.98–1.03)	0.708

*Adjusted for diabetes, chronic obstructive pulmonary disease, duration of anaesthesia, total red blood cell given, mean arterial blood pressure, smoking status and alcohol use.
ALI, acute lung injury; Fio_2, fraction of inspired oxygen; PBW, predicted body weight; PEEP, positive end expiratory pressure.

V_T bis 9 ml/kg

V_T bei Ein-Lungen-Ventilation

Intraoperative Ventilatory management

	Historical control cohort (n = 533)	PLV cohort (n = 558)
One-lung ventilation		
Tidal volume (ml/kg predicted body weight)	7.1 (1.2)	5.3 (1.1)*
Inspiratory plateau pressure (cmH_2O)	20 (7)	15 (6)*
Positive end-expiratory pressure (cmH_2O)	3.3 (2.1)	6.2 (2.4)*
Dynamic compliance (ml/cmH_2O)	32.2 (7.5)	44.6 (6.9)*
Inspiratory oxygen fraction (%)	64 (9)	67 (8)
Respiratory rate (cycle/minute)	13 (2)	15 (2)*

Postop. ALI 3,8% → 0,9% (p < 0,05)

Licker M et al. Crit Care 2009;13:R41

Fazit für die Praxis

Bei der Zwei-Lungenbeatmung ist ein intraoperatives V_T von ≤ 9 ml/kg nicht mit dem Risiko eines postoperativen ALI assoziiert.

Bei der Ein-Lungen-Ventilation muss das V_T klein gewählt werden (ca. 5 ml/kg)

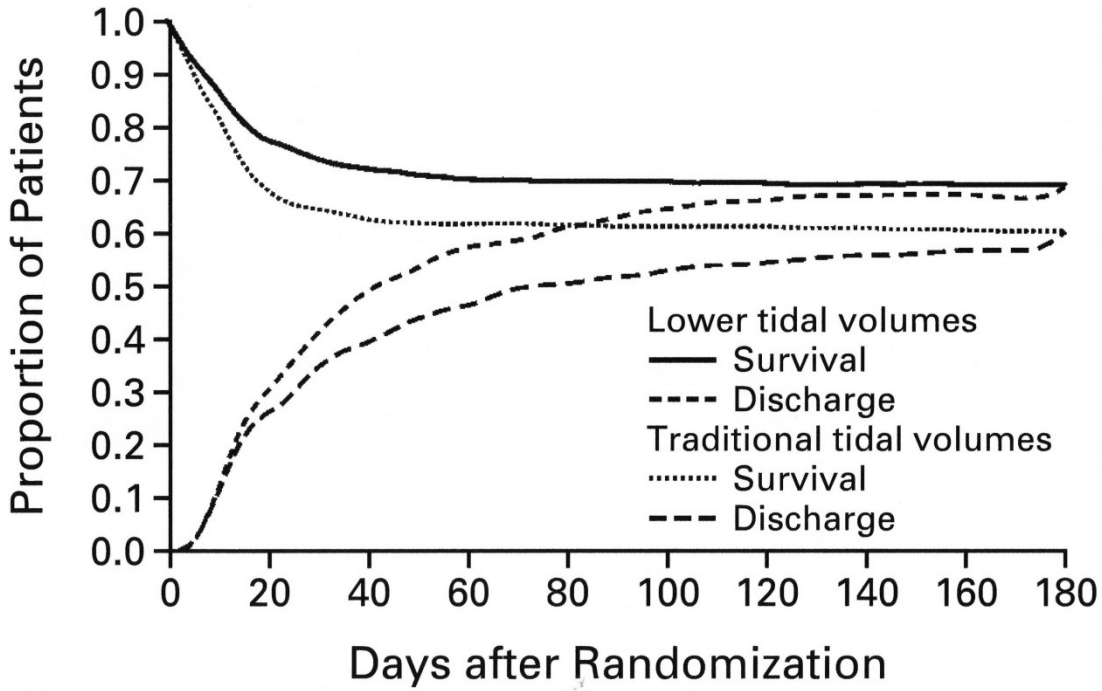
Intraoperatives Tidalvolumen

Diskussion

Tidalvolumen bei ARDS: Sind 6 ml/kg der Weisheit letzter Schluss?

State of the Art

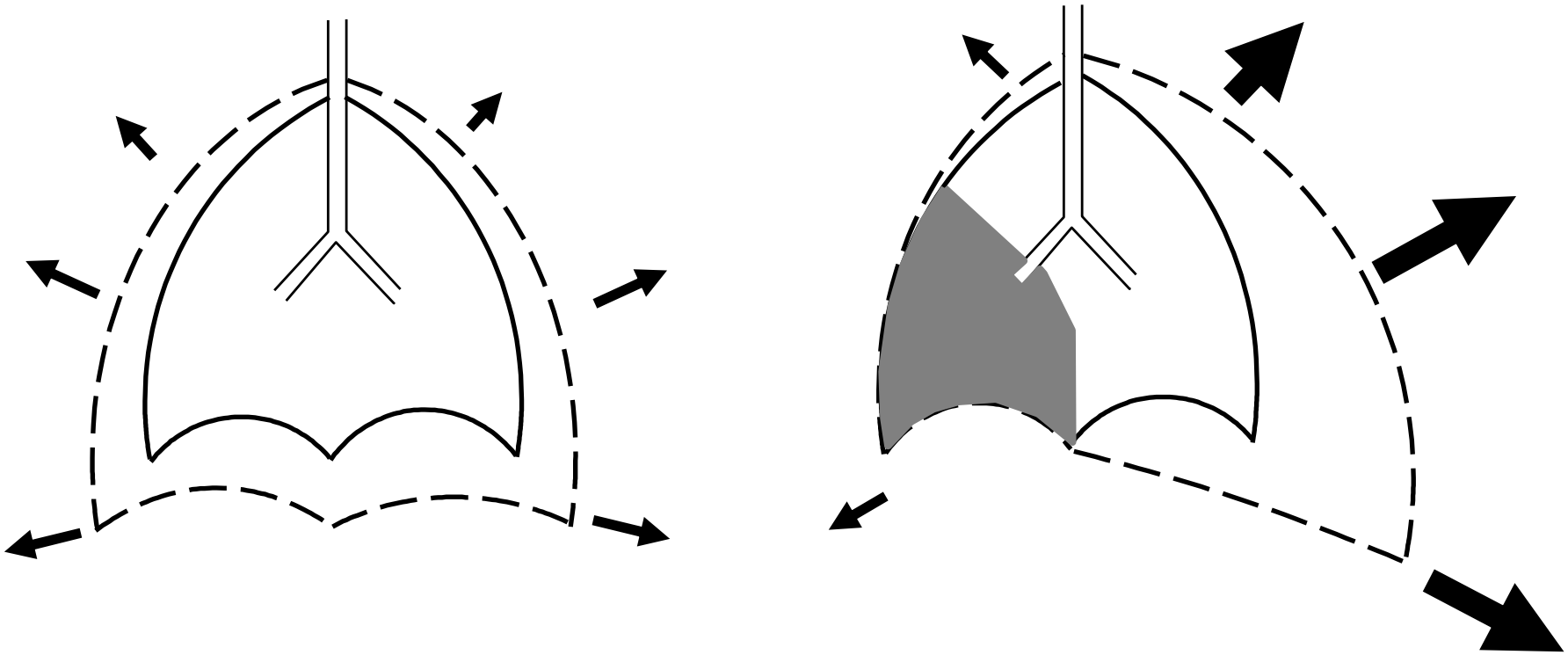
Kleine Tidalvolumina (6 vs 12 ml/kg) senken die Mortalität bei ARDS.



The ARDS Network. N Engl J Med 2000;342:1301-8

Kleines V_T bei ARDS: Rationale

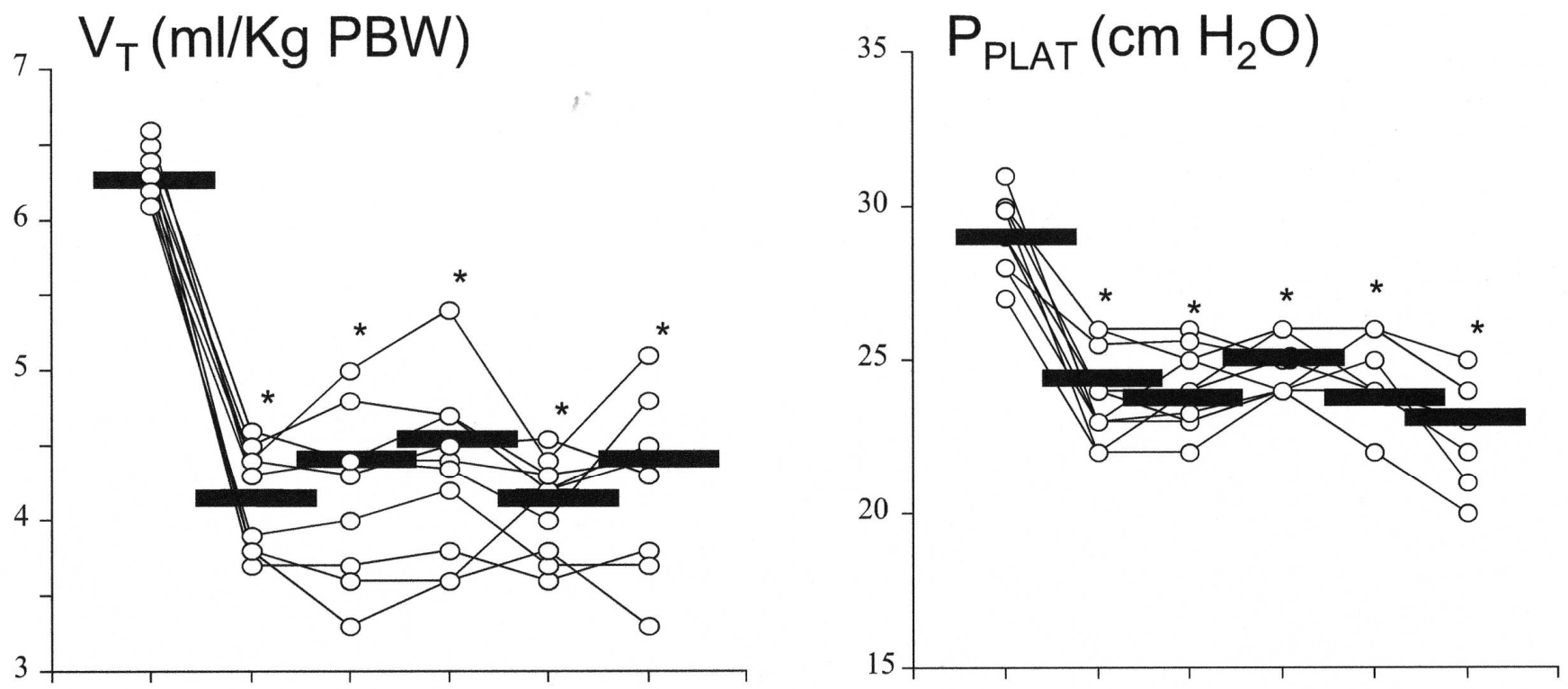
Konstantes V_T



Tidal volume lower than 6 ml/kg enhances lung protection. Role of extracorporeal carbon dioxide removal.

Terragni PP et al. Anesthesiology 2009; 111:826–35

V_T – Reduktion wenn $P_{plat} \geq 28$ mbar



V_T < 6 ml/kg: Computertomografie

	ARDSNet 28 ≤ P_{PLAT} ≤ 30	
	Study Entry (n = 10)	After 72 h of Lower *ARDSNet*/Carbon Dioxide Removal (n = 10)
Lung weight, g	1.919 ± 402*	1.519 ± 106#
End inspiratory CT lung compartments, % total lung volume		
Non-aerated (+100 and –100 HU)	23.2 ± 7.0*	12.3 ± 2.6#
Poorly aerated (–101 and –500 HU)	16.3 ± 2.8*	11.4 ± 6.7#
Normally aerated (–501 and –900 HU)	40.1 ± 9.5*	75.5 ± 8.8#
Hyperinflated (–901 and –1,000 HU)	20.4 ± 4.4*	0.8 ± 0.7#

V_T < 6 ml/kg: Inflammation

"ARDSNet" strategy: $25<P_{PLAT}<28$

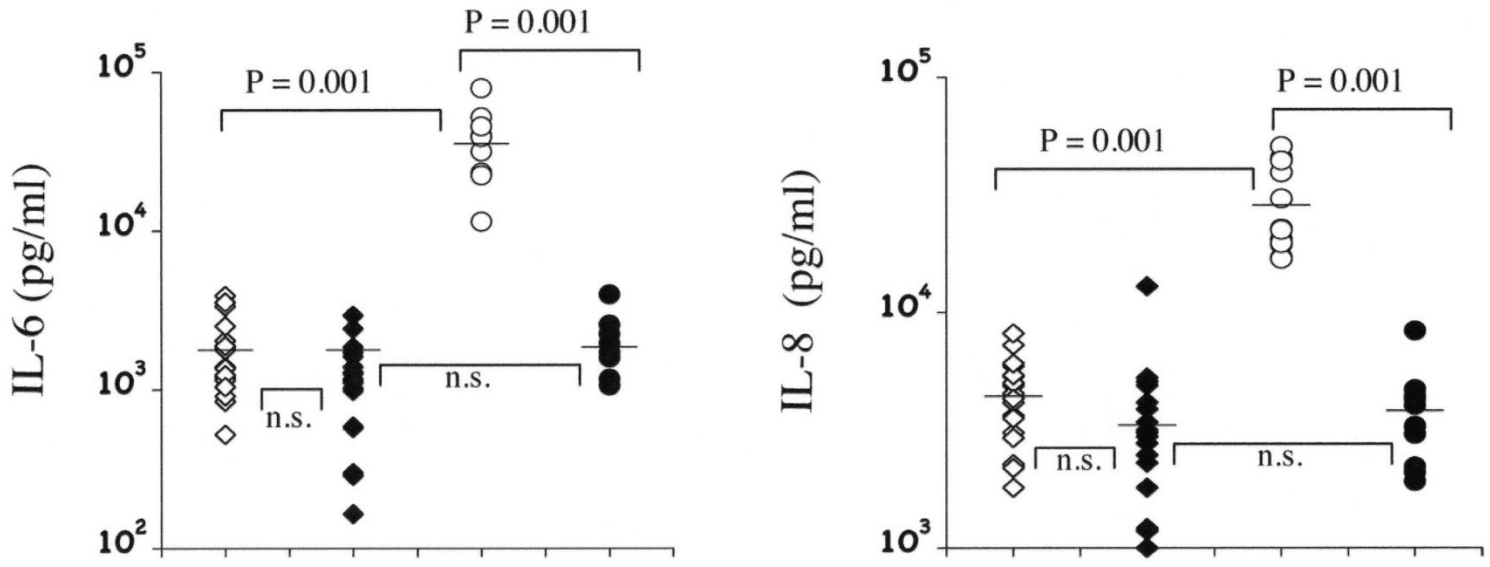
◇ *Entry (N = 22)*

◆ *after 72 hrs (N = 15)*

"ARDSNet" strategy: $28\leq P_{PLAT}\leq 30$

○ *Entry (N = 10)*

● *after 72 hrs* of *LOWER*"ARDSNet"/CARBON DIOXIDE REMOVAL *(N = 10)*



Fazit für die Praxis

Bei schwerem ARDS kann eine Reduktion des V_T unter 6 ml/kg sinnvoll sein.

Surrogat für ein „unschädliches“ V_T ist ein Atemwegsplateau-Druck ≤ 28 mbar.

Die extrakorporale CO_2 – Elimination war möglicherweise (wahrscheinlich) unnötig.

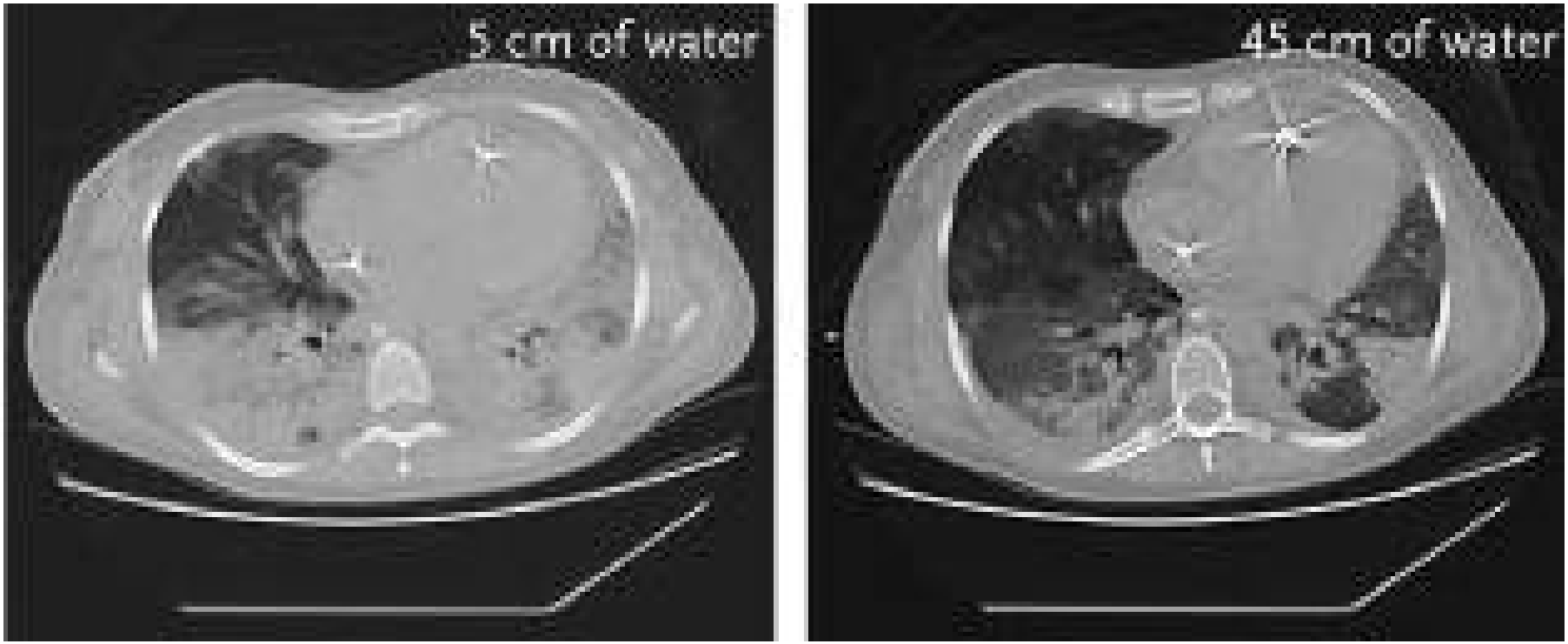
Was tun bei erhöhtem intraabdominellen Druck?

Tidalvolumen bei ARDS

Diskussion

Positiv end-exspiratorischer Druck

Ziel der PEEP-Einstellung
Recruitment ohne Überblähung

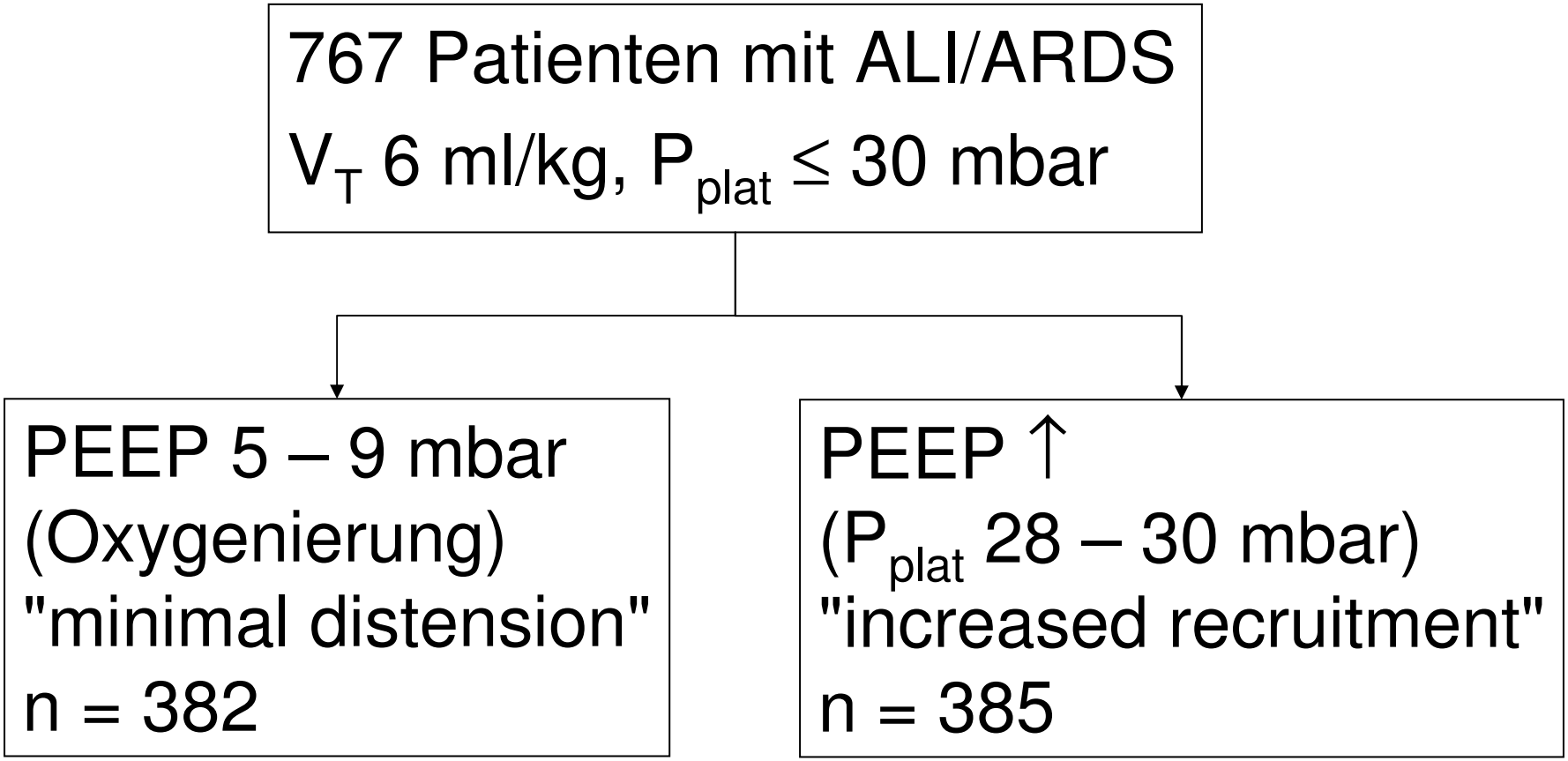


Gattinoni L et al. N Engl J Med 2006;354:1775-86

Positive end-expiratory pressure setting in adults with acute lung injury and acute respiratory distress syndrome.

The Expiratory Pressure (Express) Study Group. JAMA 2008;299:646-55

Express


767 Patienten mit ALI/ARDS
V_T 6 ml/kg, $P_{plat} \leq 30$ mbar
PEEP 5 – 9 mbar
(Oxygenierung)
"minimal distension"
n = 382
PEEP ↑
(P_{plat} 28 – 30 mbar)
"increased recruitment"
n = 385

Express

PEEP (mbar)	**7 ± 2**	**15 ± 3**
P_{plat} (mbar)	**21 ± 5**	**28 ± 2**

Outcome	Minimal Distension (n = 382)	Increased Recruitment (n = 385)	*P* Value
	No. (%)		
Death in the first 28 d[a]	119 (31.2)	107 (27.8)	.31
Death before hospital discharge	149 (39.0)	136 (35.4)	.30
Death in the first 60 d	151 (39.5)	138 (35.9)	.31
Pneumothorax between day 1 and day 28[b]	22 (5.8)	26 (6.8)	.57
	Median (IQR)		
No. of days between day 1 and day 28			
Ventilator-free[c]	3 (0-17)	7 (0-19)	.04
Organ failure–free[d]	2 (0-16)	6 (0-18)	.04
Cardiovascular failure–free[d]	21 (4-26)	23 (10-26)	.09
Renal failure–free[d]	27.5 (8.0-28.0)	28.0 (11.0-28.0)	.23

Fazit für die Praxis

Der PEEP sollte bei kleinem V_T so hoch wie möglich eingestellt werden, ohne dass der P_{plat} 28 mbar übersteigt.

Was tun bei erhöhtem intraabdominellen Druck?

Einstellung des PEEP

Diskussion

Bauchlagerung bei ARDS: Wird das Überleben verbessert?

State of the Art

Bauchlagerung verbessert häufig die Oxygenierung.

CRITICAL CARE MEDICINE
Vol. 4, No. 1

Printed in U.S.A.

Use of extreme position changes in acute respiratory failure

MARGARET A. PIEHL, RN, ROBERT S. BROWN, MD

RESULTS

Five patients who had ARDS and who required mechanical ventilation with PEEP were studied; all had documented reductions in Pao_2 below 50 torr before or in the early period of therapy. The average control Pao_2 of these patients before turning was 82 ± 3 torr. The mean Pao_2 increased 47 ± 16 torr after the patient was turned from supine to prone; all other aspects of therapy were held constant.

Überlebensstudien Bauchlagerung

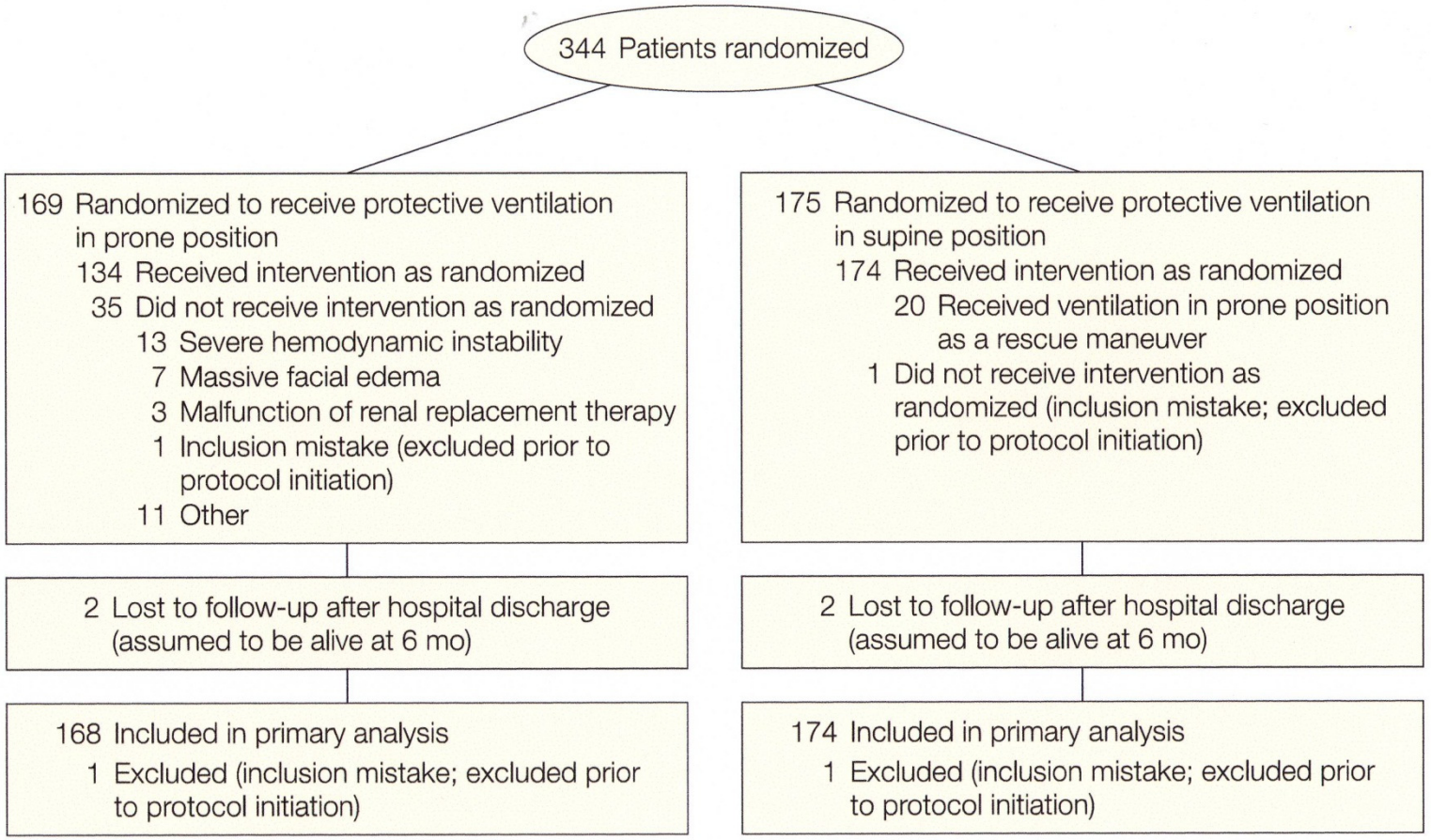
Gattinoni L et al. N Engl J Med 2001;345:568-73; Guerin C et al. JAMA 2004; 292:2379-87; Mancebo J et al. Am J Respir Crit Care Med 2006;173:1233-9

- Kein Überlebensvorteil
- Erhebliche methodische Mängel
  - Zu kurze Dauer der Bauchlage
  - Protokollverletzungen
  - Keine standardisierte Beatmung
  - Kleine Patientenzahl

Prone positioning in patients with moderate and severe acute respiratory distress syndrome.

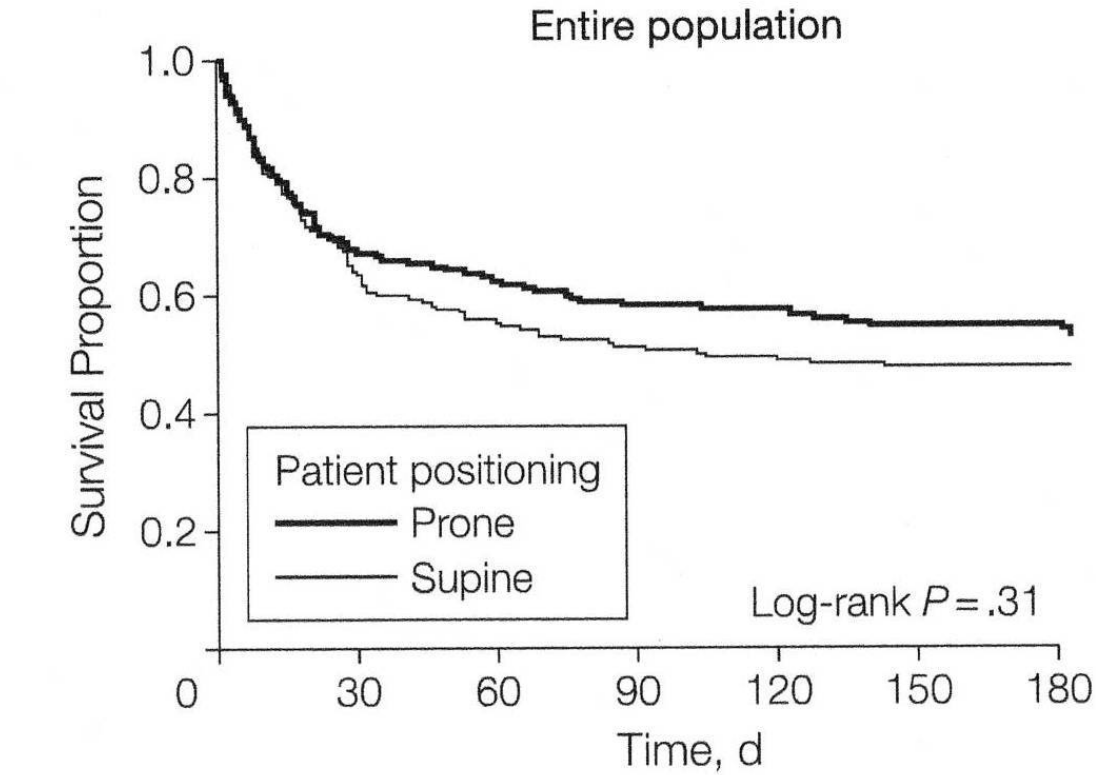
The Prone-Supine II Study Group. JAMA 2009;302: 1977-1984

Prone-Supine II Study



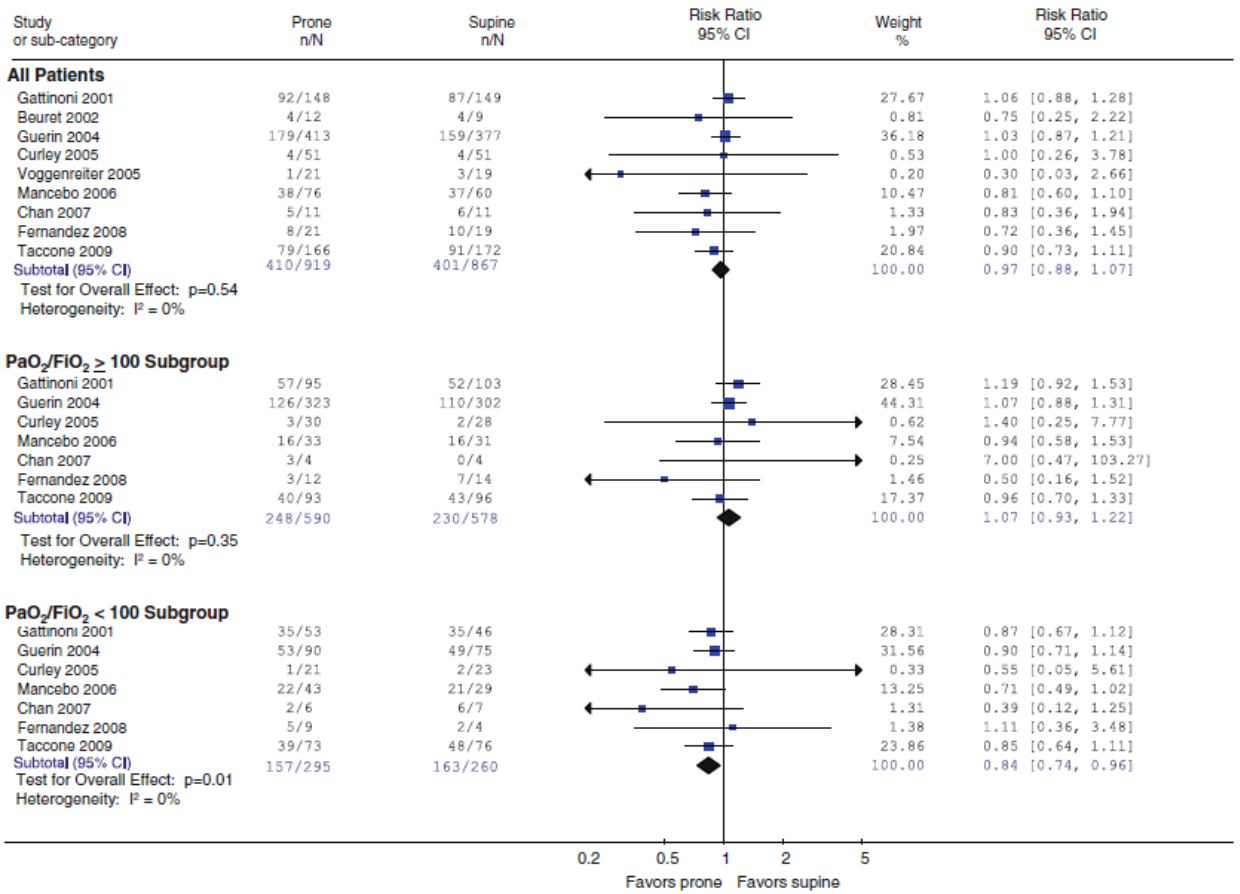
Bauchlage 20h/Tag

Prone-Supine II Study



Bauchlage Meta – Analyse

Sud S et al. Intensive Care Med 2010;36:585-99



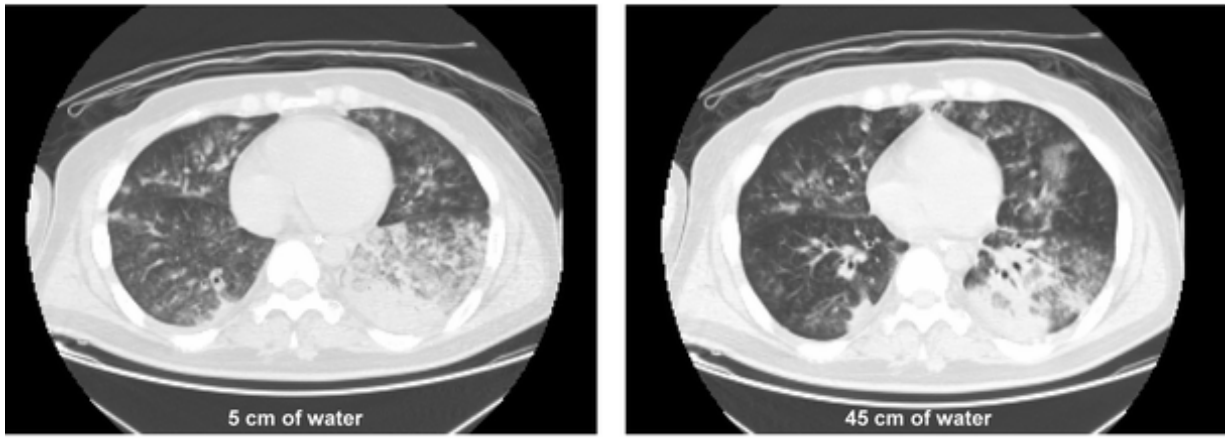
Bauchlagerung bei ARDS und alveoläres Recruitment: Pathophysiologie

Relationship between gas exchange response to prone position and lung recruitability during acute respiratory failure.

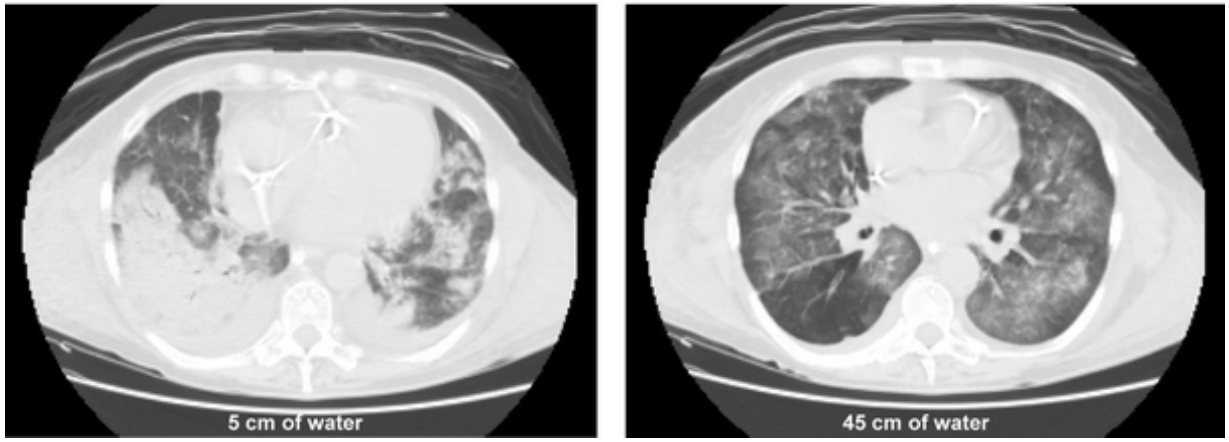
Prott A et al. Intensive Care Med 2009;35:1011-1017

Rekrutierbare Lunge

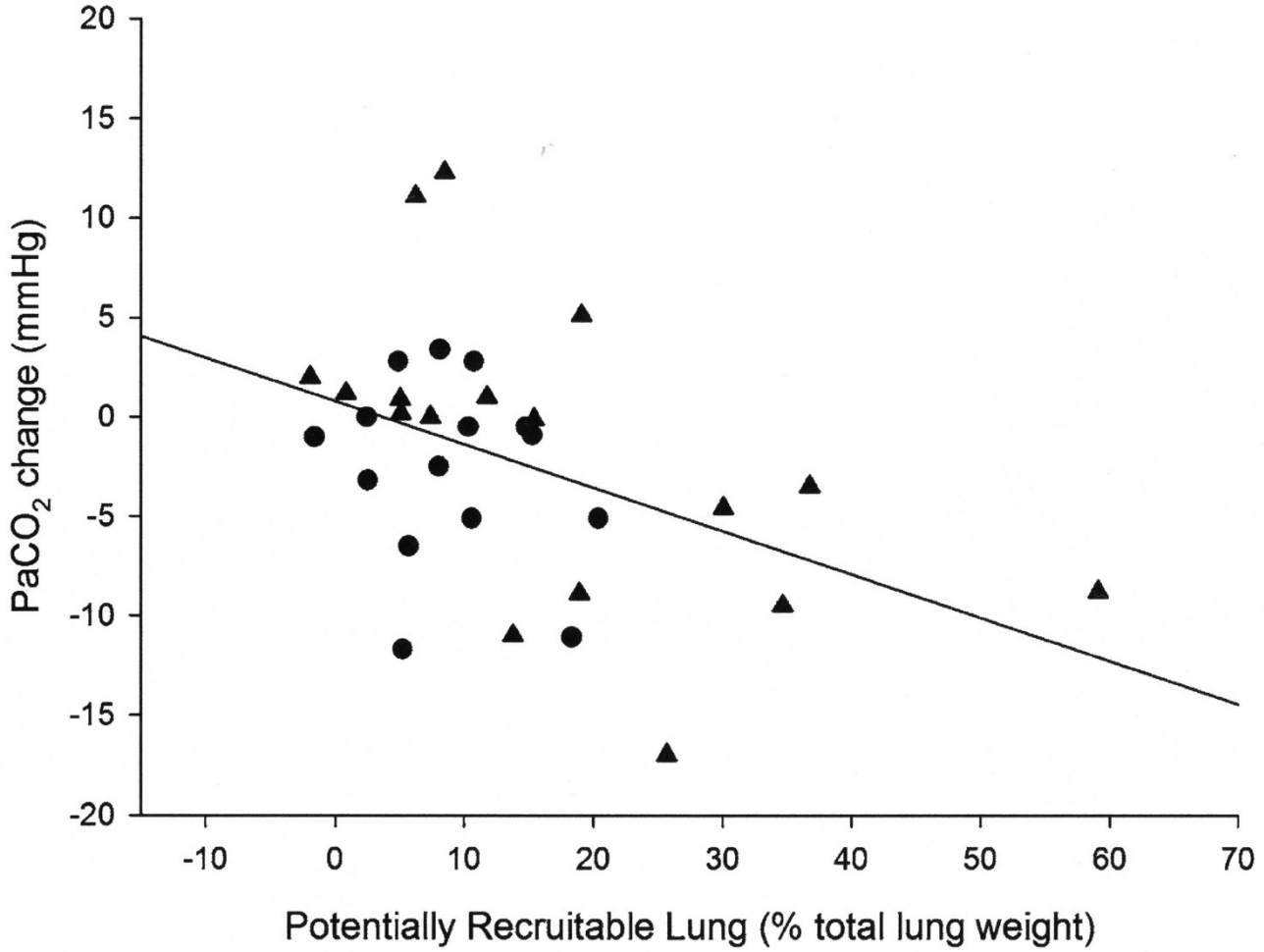
Low percentage of potentially recruitable lung



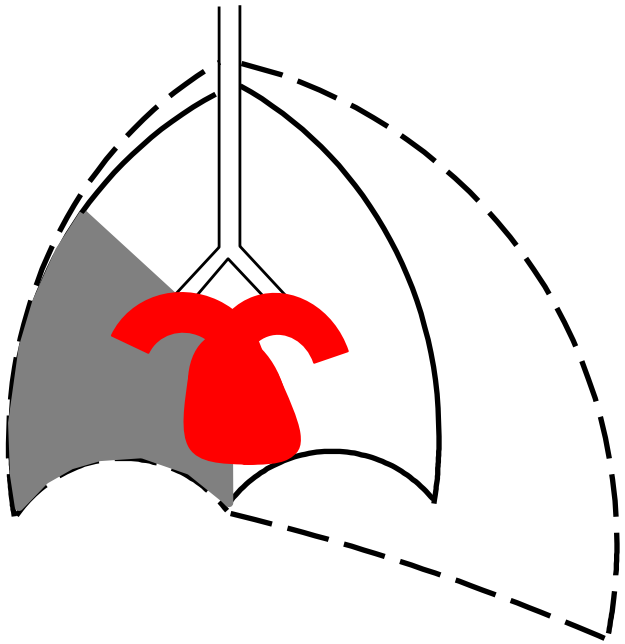
High percentage of potentially recruitable lung



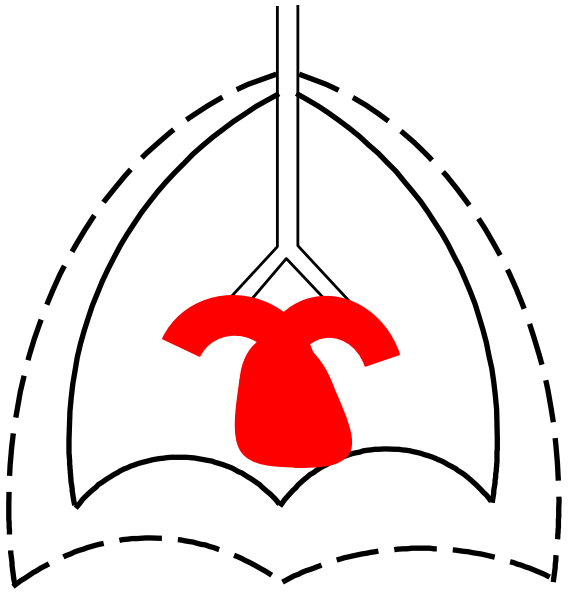
Rekrutierbare Lunge und $PaCO_2$



Ventilations-Perfusions-Verhältnis $PaCO_2$



Ventilierte Lunge: $\dot{V}_A/\dot{Q}$ hoch



$\dot{V}_A/\dot{Q}$ ↓

Fazit für die Praxis

Das Überleben von Patienten mit ARDS wird durch Bauchlagerung bei schwerer Hypoxämie ($PaO_2/FIO_2 < 100$ mmHg) verbessert.

Lagerungs-induziertes alveoläres Recruitment erkennt man am sichersten durch einen Abfall des $PaCO_2$.

Bauchlagerung

Diskussion