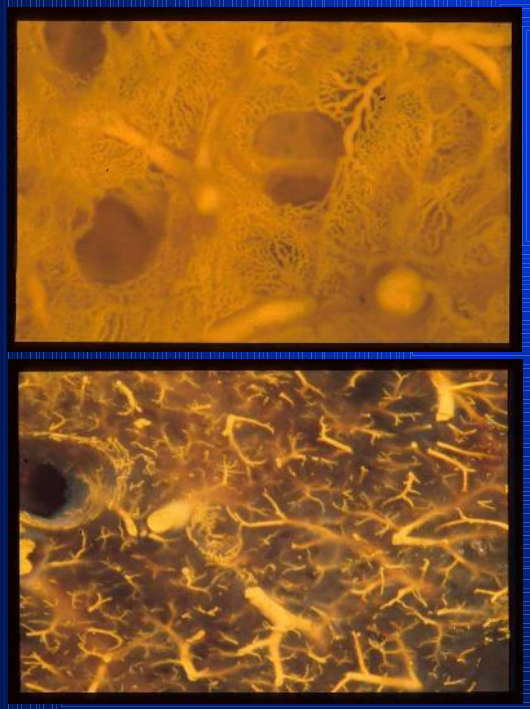
THE ROLE OF ECHOCARDIOGRAPHY IN THE MANAGEMENT OF ARDS

FOCUS ON RV FUNCTION

Antoine Vieillard-Baron, Boulogne, France

ARDS MAY DEGRADE RV FUNCTION BY INCREASING AFTERLOAD

- By causing damage to the pulmonary circulation



W Zapol

- By inducing pulmonary vascular remodeling

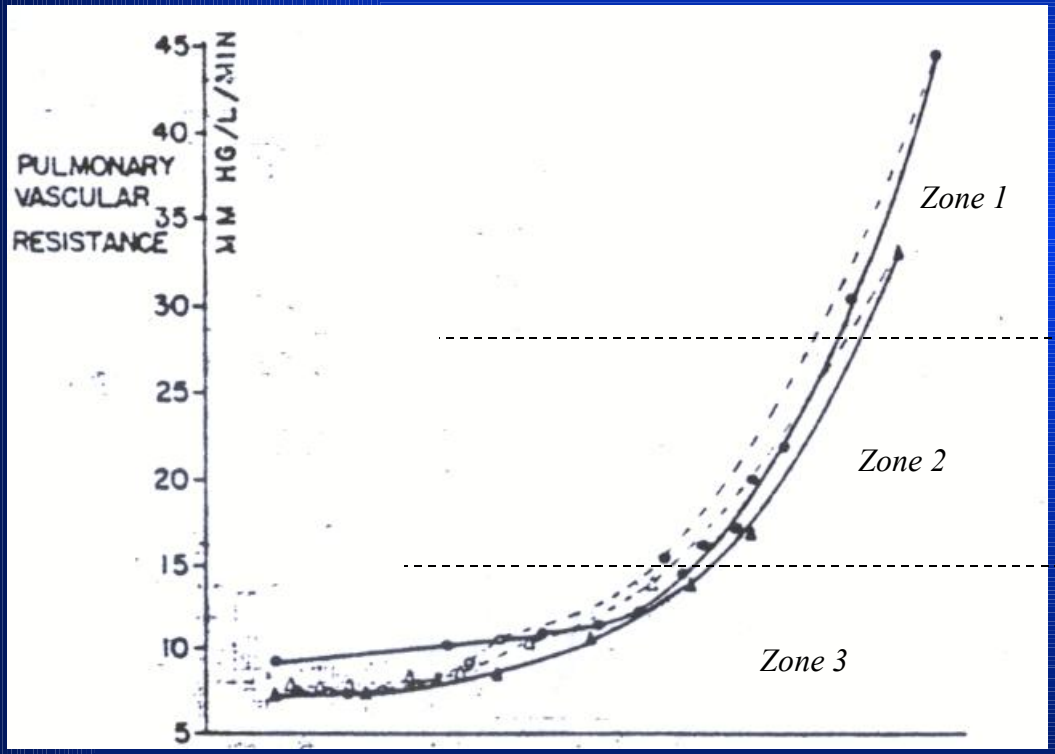
Table 1.–Factors contributing to pulmonary hypertension in acute respiratory distress syndrome

Functional	Mediator-induced vasoconstriction
	Hypoxic pulmonary vasoconstriction
Structural	Vascular compression by oedema fluid or fibrosis
	Vascular wall remodelling
	Thromboembolism
	Reduced lung volume

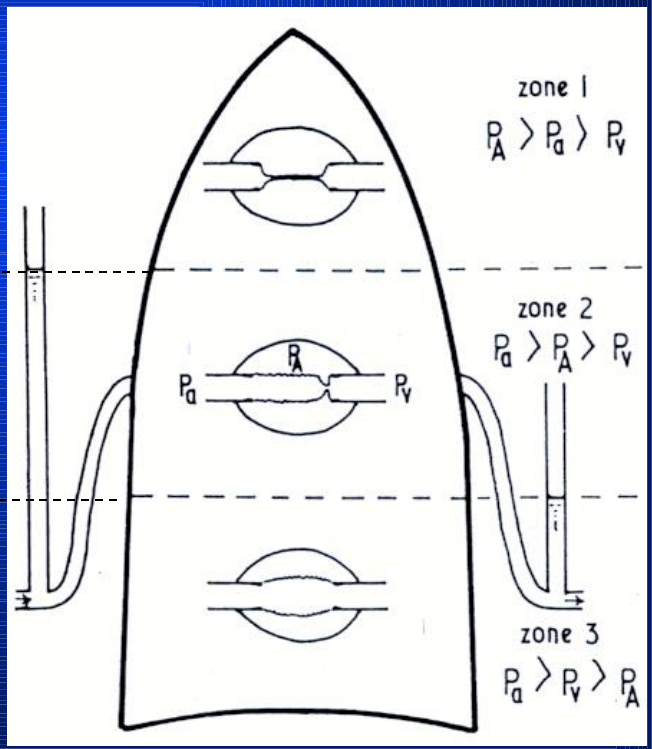
Moloney Eur Respir J 2003

MECHANICAL VENTILATION MAY ALSO DEGRADE RV FUNCTION

Whittenberger JAP 1960



West JAP 1964



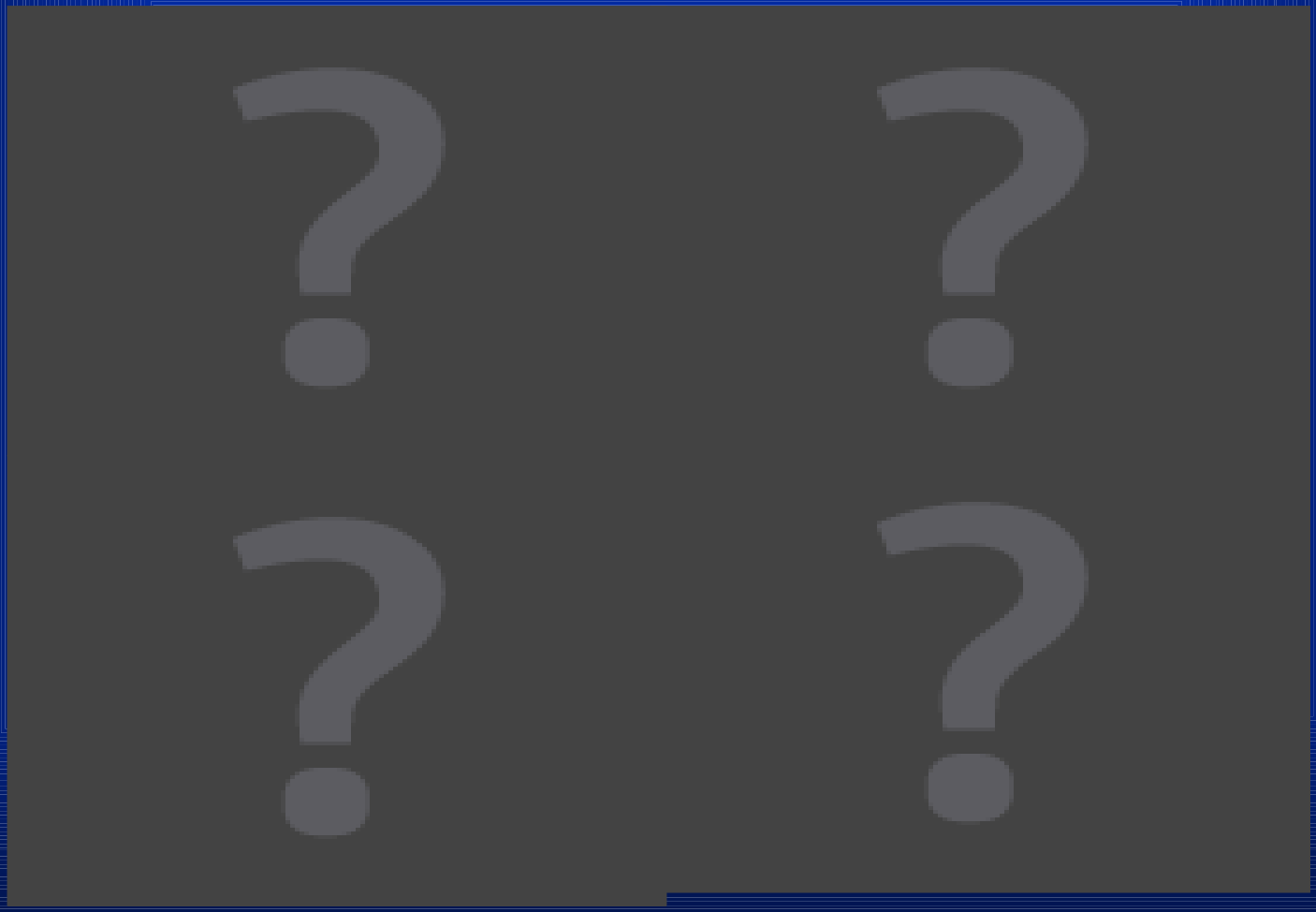
CONSEQUENCES OF SUCH EFFECTS: ACP

LV long axis view

LV short axis view

No ACP

ACP



RV diastolic overload

RV systolic overload

ECHOCARDIOGRAPHY PERMITS RESPIRATORY SUPPORT TO BE ADAPTED TO RV FUNCTION

Towards a “right ventricular protective approach”

	"historical" ARDS (n = 33)	"recent" ARDS (n = 37)
TV (ml/kg)	13 ± 2	9 ± 2*
EIP (cm H_2O)	39 ± 4	25 ± 4*
EEP (cm H_2O)	10 ± 4	6 ± 4*
$PaCO_2$ (mm Hg)	36 ± 6	51 ± 10*

Jardin ICM 1999

Monitoring

Incidence of Acute Cor Pulmonale

61%
Jardin CCM 1985

25%
Vieillard-Baron CCM 2001

Mortality 64%

Mortality 32%

I

ADAPT PLATEAU PRESSURE

Predictors of ACP

23 ARDS 1985

Jardin CCM 1985

75 ARDS 1996-2001

Vieillard-Baron CCM 2001

	No ACP (65)	ACP (33)	univariate	multivariate
Age	52 ± 17	48 ± 16	NS	
IGS II	54 ± 17	51 ± 13	NS	
PaO_2/FIO_2 (mmHg)	131 ± 53	104 ± 31	0.005	NS
$PaCO_2$ (mmHg)	45 ± 10	45 ± 13	NS	
TV (ml/kg)	9.3 ± 2.3	10.7 ± 2.8	0.1	NS
Crs (ml/cm H_2O)	38 ± 8	31 ± 7	0.0000	NS
Plateau (cm H_2O)	25 ± 7	37 ± 12	0.0000	0.04
PEEP(cm H_2O)	6 ± 4	10 ± 4	0.0000	NS

François Jardin
Antoine Vieillard-Baron

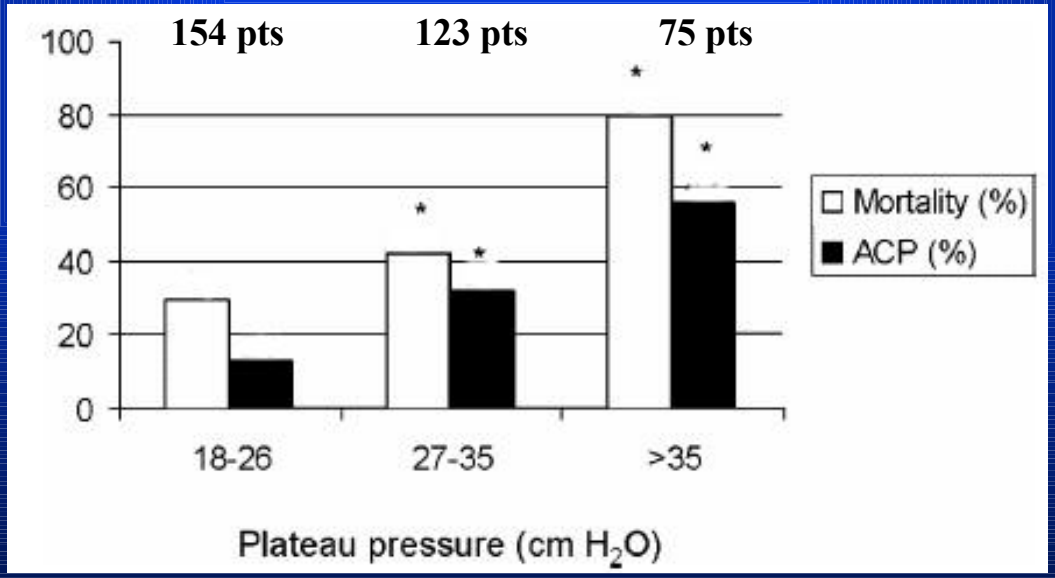
Is there a safe plateau pressure in ARDS? The right heart only knows

ICM 2007

1980-2006
352 ARDS with ECHO

1980-1992
156 ARDS
No limitation in PP

1993-2006
196 ARDS
Low stretch strategy

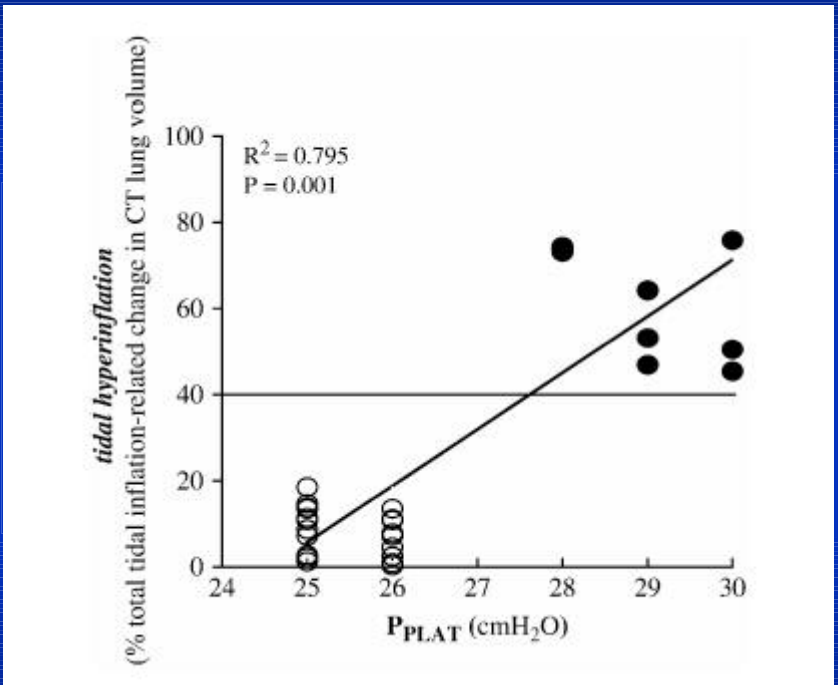


400 x 25
PEEP 5
PP 33

SAP 92 mmHg

350 x 25
PEEP 5
PP 26

SAP 123 mmHg



Terragni et al. Am J Respir Crit Care Med 2007

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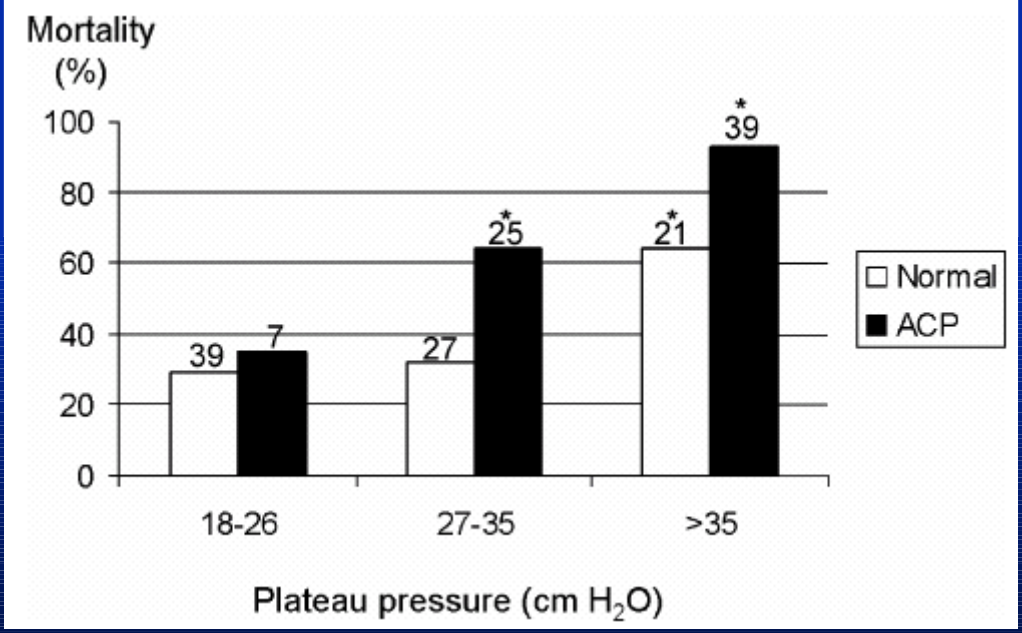


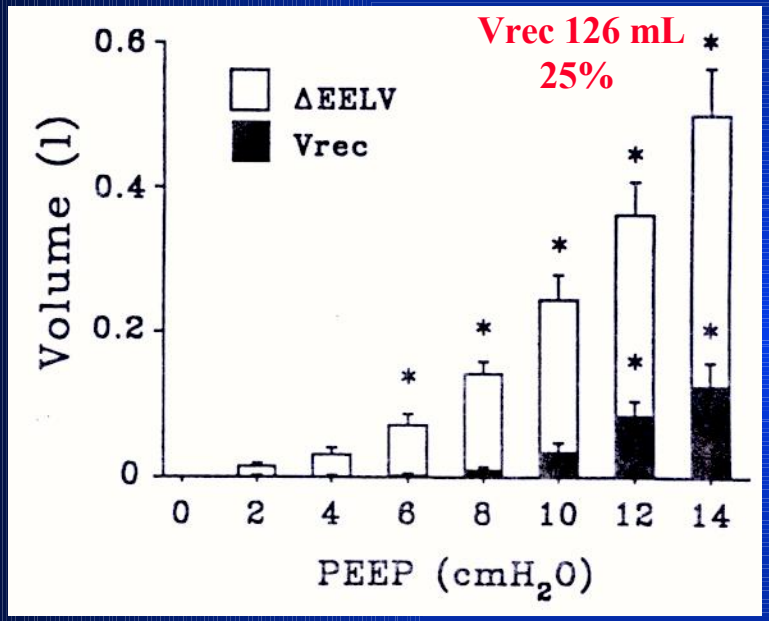
	Parameters	Odds ratio	PP, PEEP
Monchi *AJRCCM 1998* *1992-1995*	Pra > Ppao	5.1 [1.5-17.1]	PP 31 [27-38]
Squara *ICM 1998* *1985-1987*	RVSW/LVSW (%)	[10-35]	High PP
Richard C *SRLF 2004* *1999-2001*	Pra > Ppao	2.11 [1.10-4.03]	?
Vieillard-Baron *CCM 2001* *1996-2001*	ACP ECHO	NS	PP<27 PEEP 7 ± 3 Prone position

128 ARDS between 1998 and 2006
PEEP 6 +/- 1 cmH_2O [5-9]

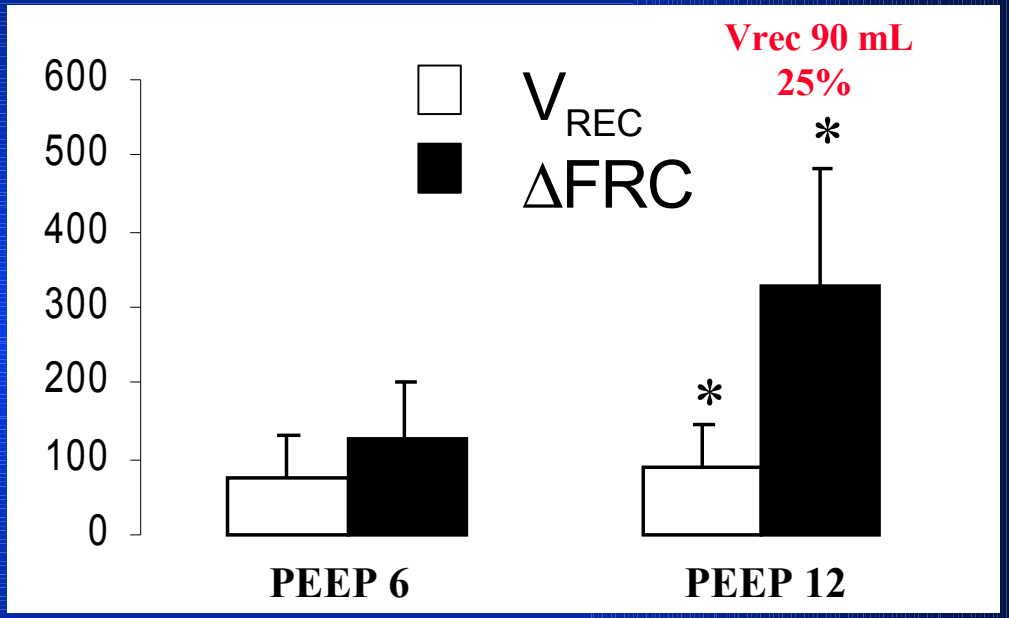
C_{rs} ml/cmH_2O	n	TV ml/kg	Pplateau cmH_2O	P/F_3 mmHg	$PaCO_2$ mmHg	PP n (%)
< 20	10	5.1±0.3	29±1	99±49	59±11	6 (60)
20-25	26	6.2±0.5	27±3	104±48	49±11	14 (54)
26-30	28	7.7±0.7	26±2	134±68	47±10	7 (25)
31-35	16	8.2±0.6	23±3	145±58	45±7	3 (19)
36-40	30	8.3±0.4	22±3	164±75	46±9	4 (13)
> 40	18	8.6±0.4	20±2	161±76	40±7	2 (11)

II

LIMIT PEEP

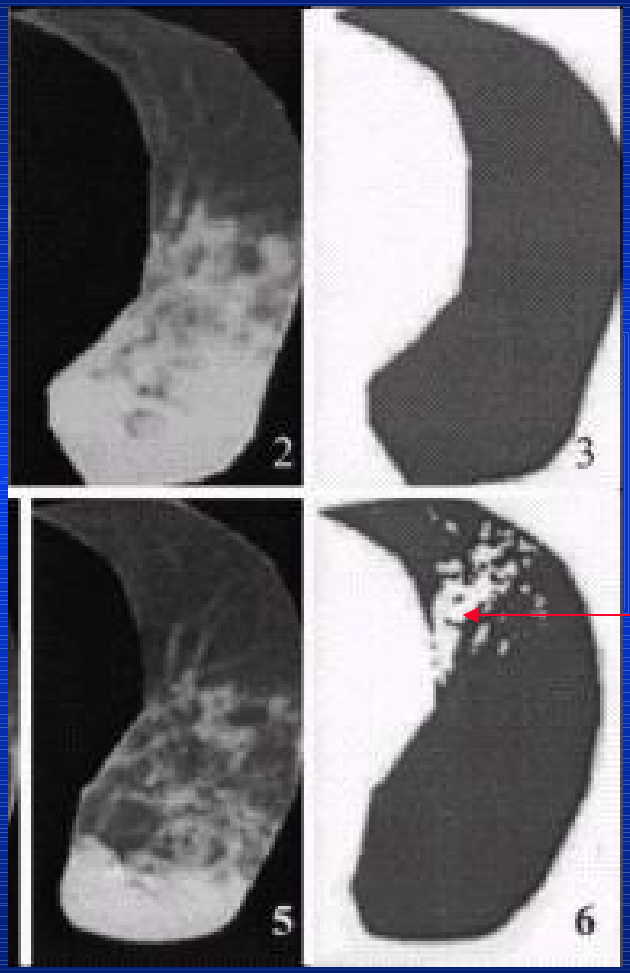


Valta JCC 1993



Vieillard-Baron ICM 2003

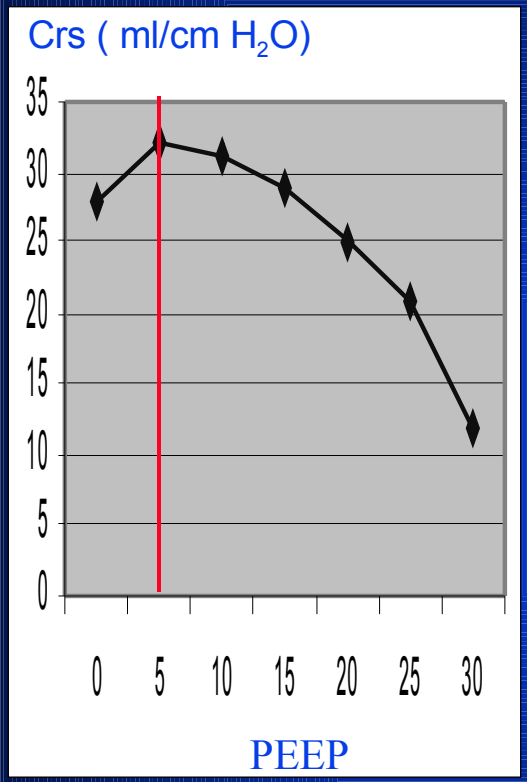
ZEEP



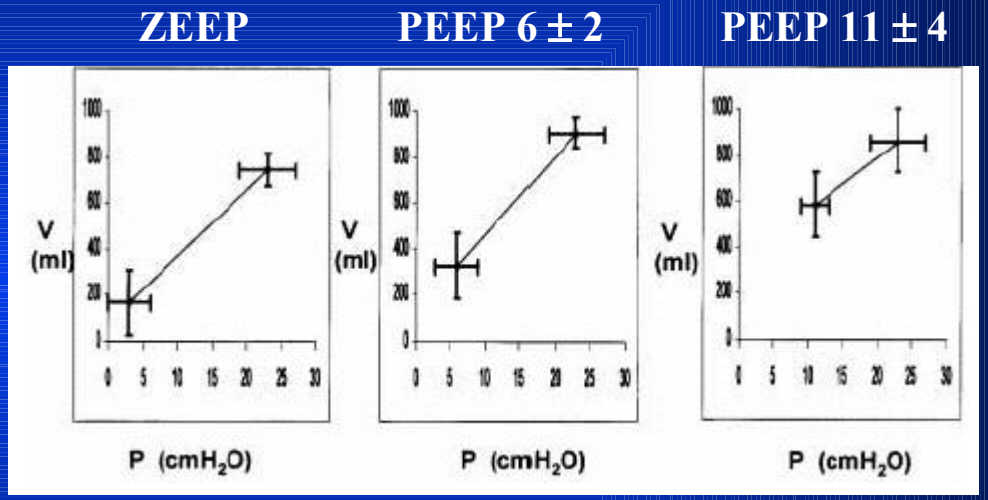
PEEP 15

Overdistension
Anterior area

Rouby CCM 2004

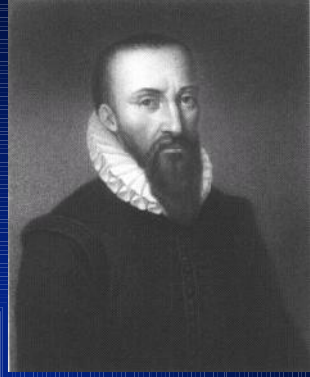


Jardin N Engl J Med 1981

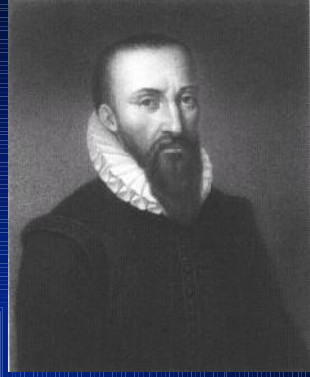


Vieillard-Baron AJRCCM 2002

- **Prospective and preliminary study**
  - **2 French centers (AP-HM)**
  - **11 patients with severe ARDS**
  - **P/F 88 [60-110]**

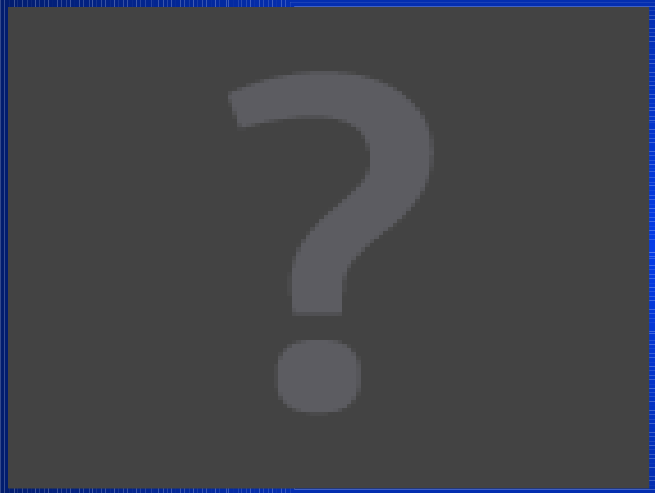


	MODE A	MODE B
PEEP (cmH_2O)	6 [5-7]	12 [11-12]*
TV (ml)	548 [468-605]	336 [260-360]*
PP (cmH_2O)	24 [22-27]	24 [22-27]
RR (/min)	15 [15-20]	26 [25-30]*
P/F	88 [60-110]	103 [74-138]*
$PaCO_2$ (mmHg)	52 [43-68]	71 [60-94]



	MODE A	MODE B
HR	107 [80-114]	112 [93-118]*
BD (mmol/l)	0 [-5.4 to 1]	-3.7 [-6.45 to –0.3]*
EDA RV/LV	0.6 [0.6-0.8]	0.9 [0.6-1.1]*
LVEIs	1.10 [1.02-1.25]	1.19 [1.07-1.54*]*
RVSI (ml/m^2)	23 [21-36]	18 [11-21]*

PEEP 7 PP 27



SI_{RV} 23 ml/m²
SAP 135 mmHg
HR 100/mn

PEEP 14 PP 27

SI_{RV} 12 ml/m²
SAP 115 mmHg
HR 121/mn

PEEP 6 PP 28

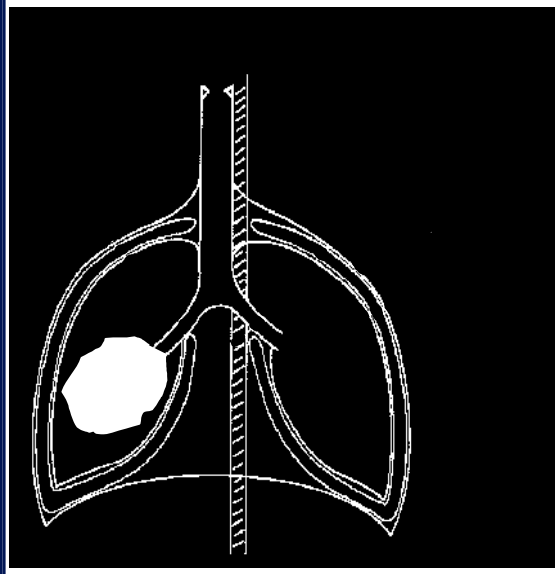
PEEP 12 PP 28

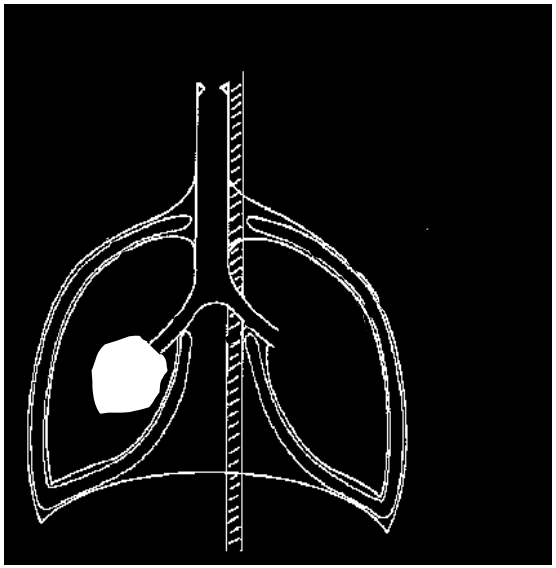
IV

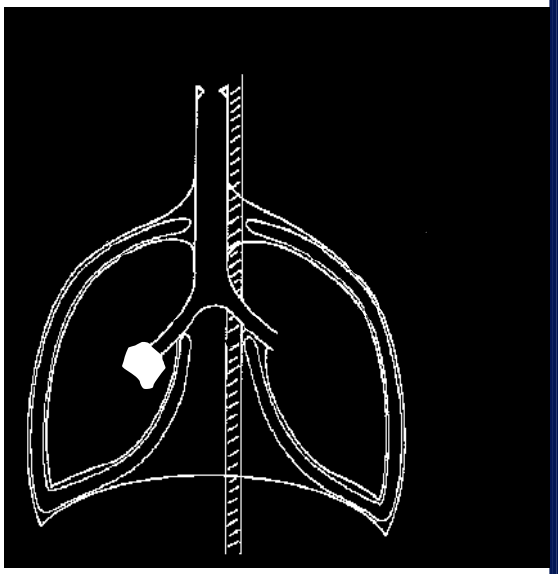
EFFECT OF $PaCO_2$ ON RV FUNCTION

THE CONCEPT OF " BABY LUNG"

(predicted body weight : 75 kg)







Crs 35ml/cmH_2O

Pplat 28 cm H_2O
PEEP 15 cm H_2O

TV : 6 ml/kg

Crs 25ml/cmH_2O

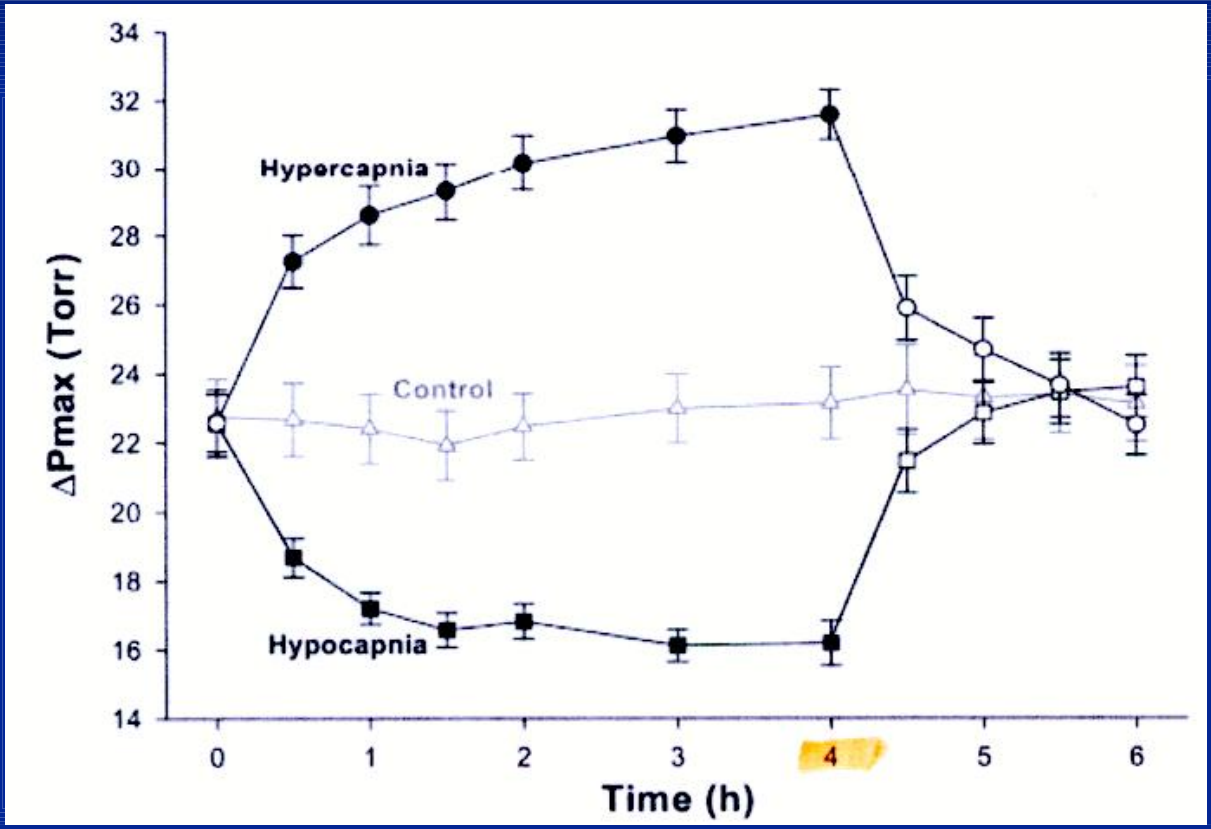
Pplat 28 cm H_2O
PEEP 15 cm H_2O

TV : 4 ml/kg

Crs 15ml/cmH_2O

Pplat 28 cm H_2O
PEEP 15 cm H_2O

TV : 2.6 ml/kg !!!!



Balanos J Appl Physiol 2003

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Antoine Vieillard-Baron

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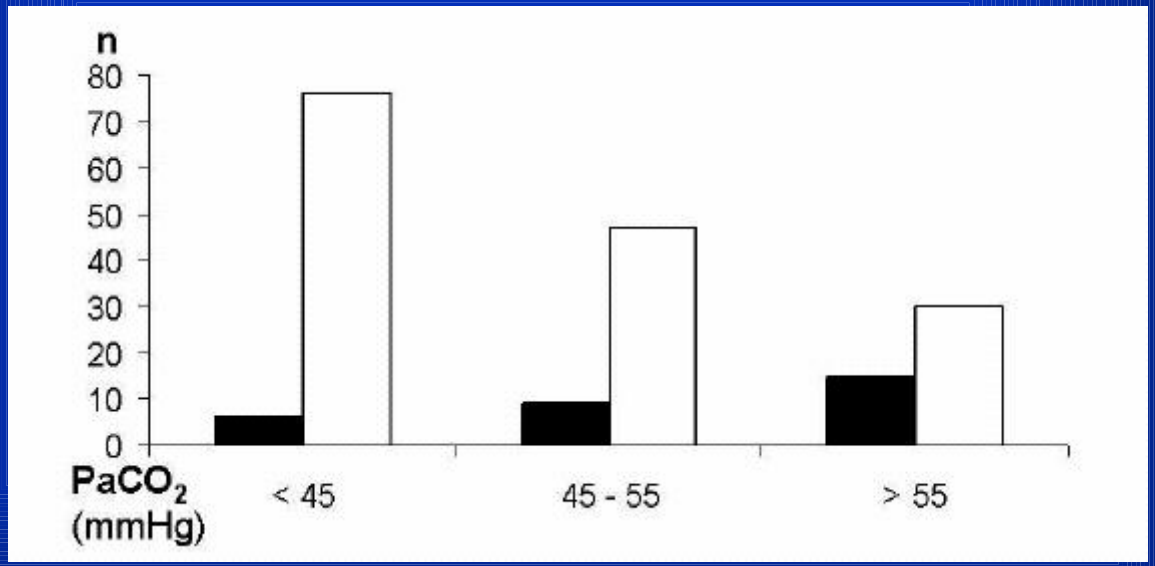
ICM 2007



SO, HYPERCAPNIA SHOULD BE LIMITED

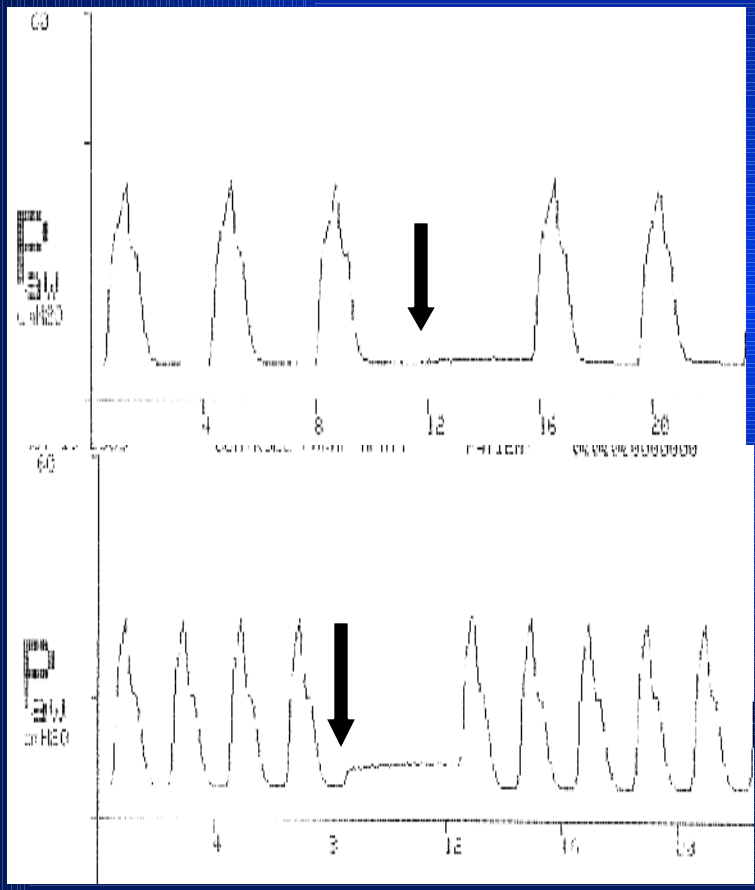


Table 4. Comparison between Doppler hemodynamic measurements obtained with a respiratory rate (RR) of 15 breaths/min (RR 15) and a respiratory rate of 30 breaths/min (RR 30)

	RR 15	RR 30
ICT, msec	46 ± 18	60 ± 18[a]
FP, msec	234 ± 36	230 ± 35[b]
V_{MAX}, m/sec	0.88 ± 0.20	0.79 ± 0.17[a]
PA_{VTI}, cm	12.9 ± 2.3	11.6 ± 2.6[a]
IVC diam, mm	18 ± 5	21 ± 5[a]
HR, beats/min	115 ± 11	115 ± 11
SI, cm^3/m^2	29 ± 5	26 ± 5[a]
CI, $L/min/m^2$	3.3 ± 0.7	2.9 ± 0.6[a]

ICT, isovolumic contraction time; FP, flow period; V_{MAX}, peak velocity; PA_{VTI}, pulmonary artery velocity-time integral; IVC diam, inferior vena caval diameter; HR, heart rate; SI, stroke index; CI, cardiac index.

[a] $p < .05$; [b] NS, not significant. Values are mean ± SD.

Vieillard-Baron CCM 2002

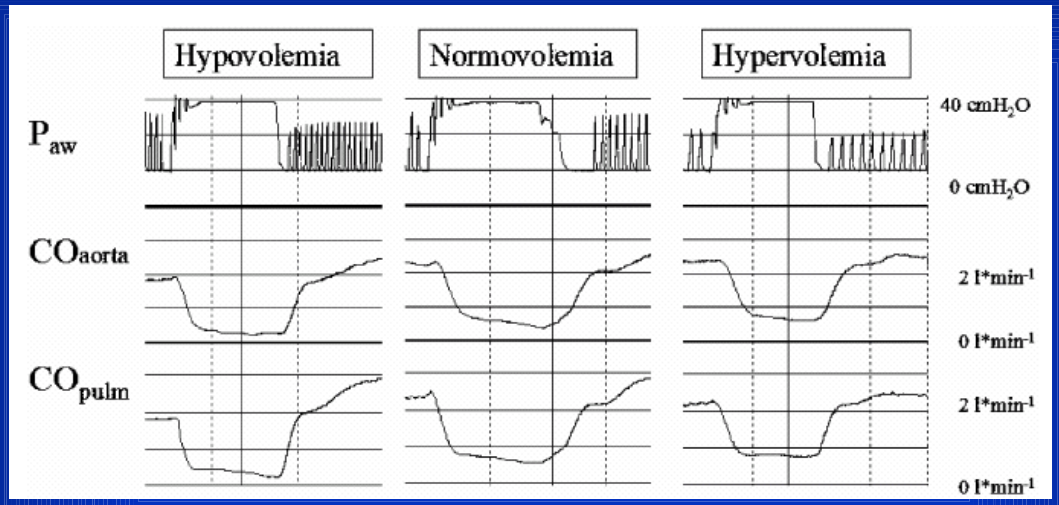
III

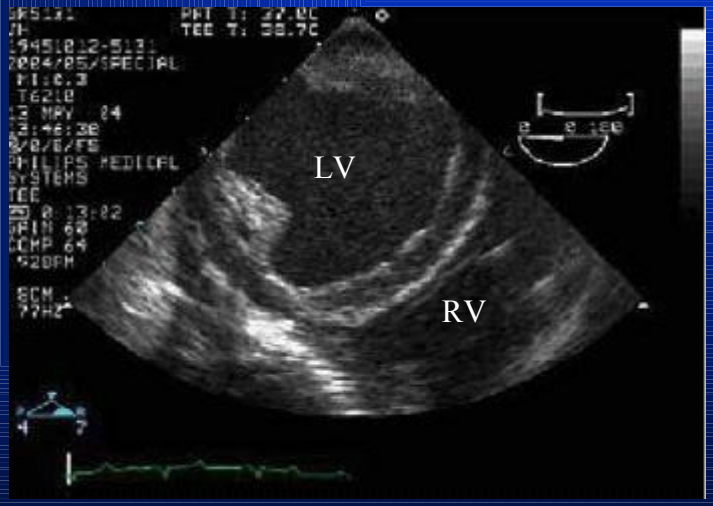
OBSERVE DELETERIOUS EFFECTS OF RECRUITMENT MANEUVERS

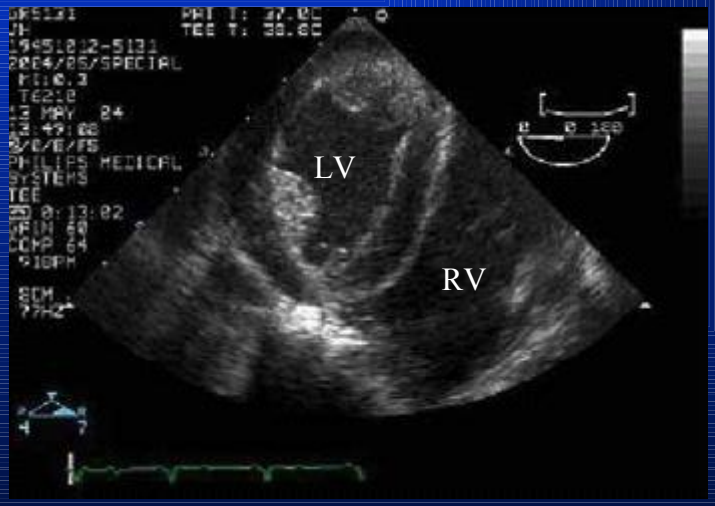
Jonas Nielsen
Manja Nilsson
Filip Fredén
Jan Hultman
Ulrica Alström
Jesper Kjærgaard
Göran Hedenstierna
Anders Larsson

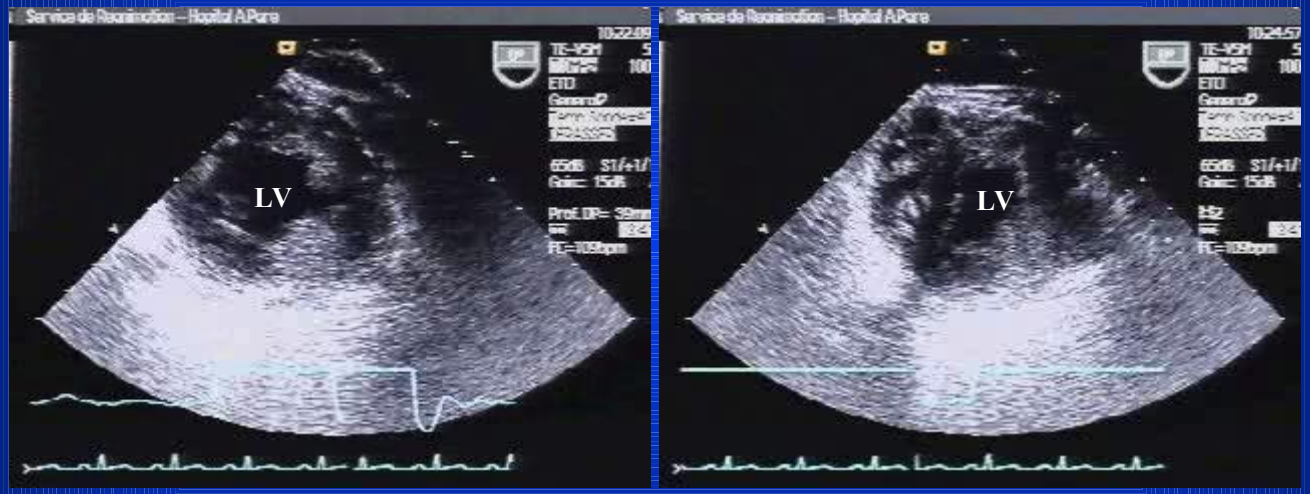
Central hemodynamics during lung recruitment maneuvers at hypovolemia, normovolemia and hypervolemia. A study by echocardiography and continuous pulmonary artery flow measurements in lung-injured pigs

ICM 2006









A B

Vieillard-Baron ICM 2006

V

HOW TO DO?

1- To improve oxygenation

2- To protect the right ventricle

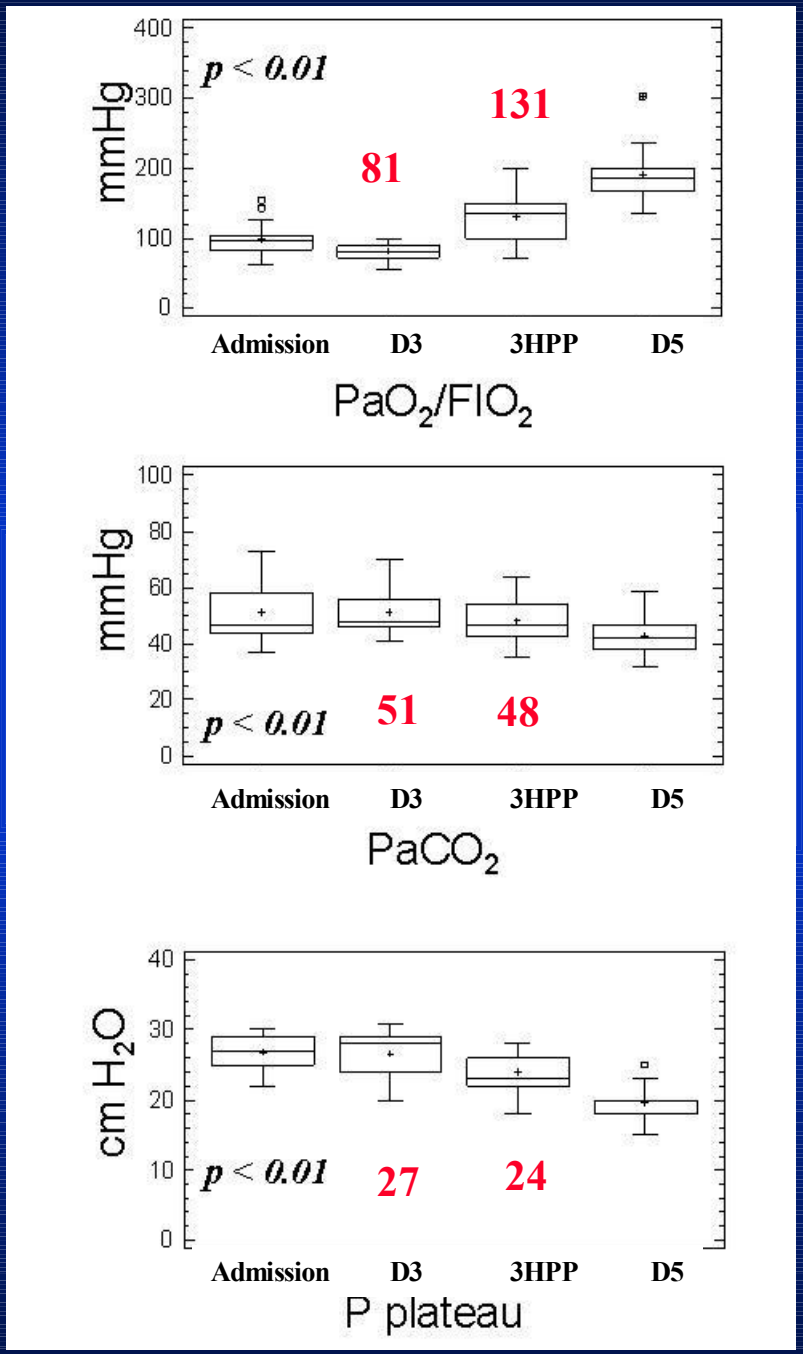
- by limiting PP
- by limiting PEEP
- by limiting hypercapnia

LOW STRETCH STRATEGY 1994-2006

Crit Care Med 2003

219 patients with ARDS

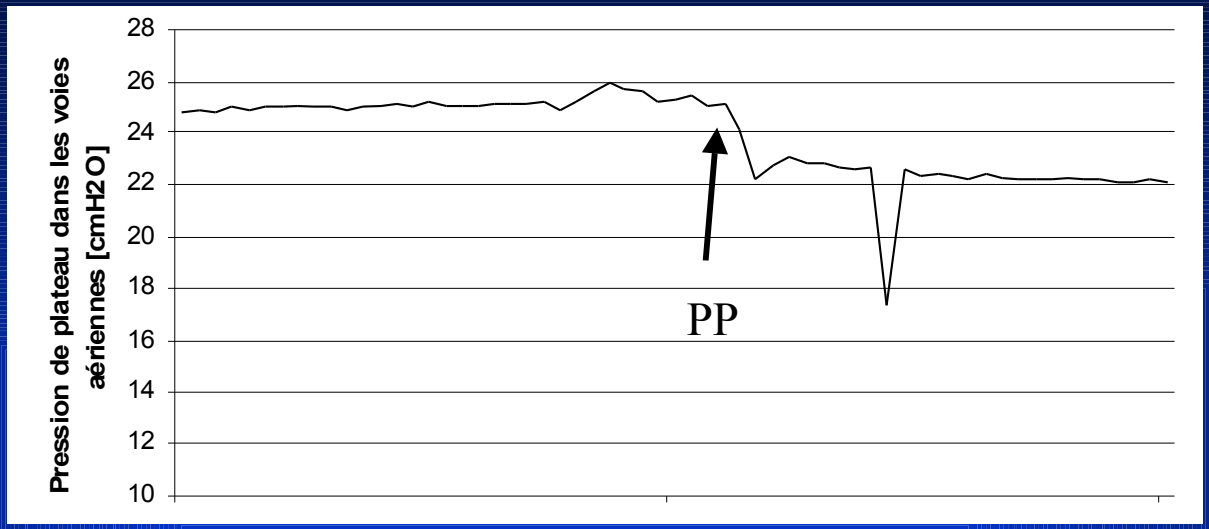
- **55 years old**
- **SAPS II 55, predicted mortality rate 50%**
- **Crs 33 ml/cmH_2O**
- **Echo at Day 1, 2, 3**
- **Adapt plateau pressure to RV function**
- **Limit PEEP between 5 to 7 cmH_2O in all patients**
- **Prone position in severely hypoxemic patients or in patients with ACP**
  - » **(30% of patients)**
- **Hospital mortality rate 31%**

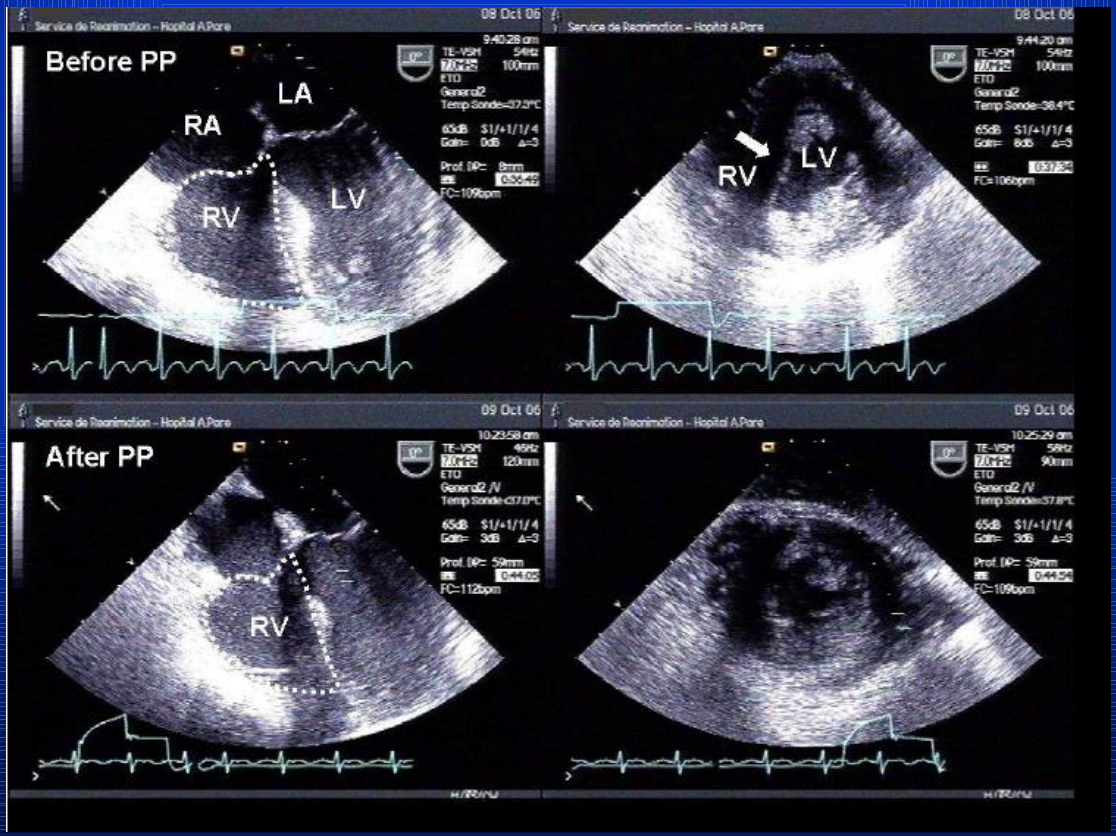

400
300
200
100
0
mmHg
p < 0.01
131
81
Admission
D3
3HPP
D5
PaO2/FIO2
100
80
60
40
20
0
mmHg
p < 0.01
51
48
Admission
D3
3HPP
D5
PaCO2
40
30
20
10
0
cm H2O
p < 0.01
27
24
Admission
D3
3HPP
D5
P plateau

Group 1 (n=21)	Before PP	After 18h PP	p value
Plateau pressure (cm H_2O)	27±3	25±3	0.000
PaO_2/FiO_2 (mmHg)	74±18	115±40	0.000
$PaCO_2$ (mmHg)	54±8	50±9	0.005

Group 1 (n=21)	Before PP	After 18 h of PP	p value
SAP (mmHg)	115±12	117±14	ns
HR (beats/min)	107±15	100±13	0.019
CI ($L/min/m^2$)	2.9±0.8	3.4±0.8	0.013
RVEDA/LVEDA	0.91±0.22*	0.61±0.21	0.000
Eccentricity	1.5±0.2*	1.1±0.1	0.000
LVEDV (ml/m^2)	45±13*	64±21	0.000
LVEF (%)	58±11	60±9	ns

Chest in press


Pression de plateau dans les voies aériennes [cmH2O]
28
26
24
22
20
18
16
14
12
10
PP


Before PP
LA
RA
RV
LV
RV
LV
After PP
RV

THANK YOU