FONCTION VD DANS LE SDRA

Antoine Vieillard-Baron, Boulogne, France

LE RATIONEL

LE SDRA EST UNE MALADIE DES ALEOLES MAIS AUSSI DE LA CIRCULATION PULMONAIRE

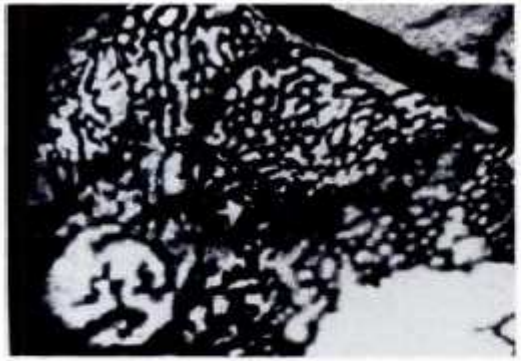
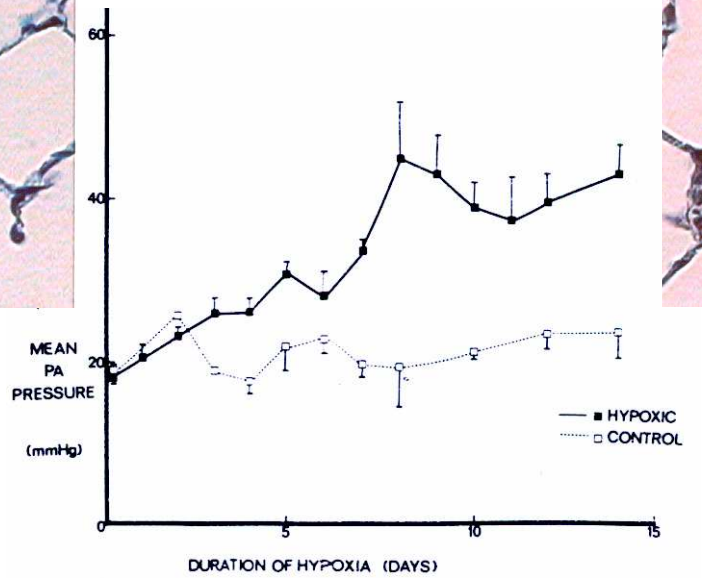
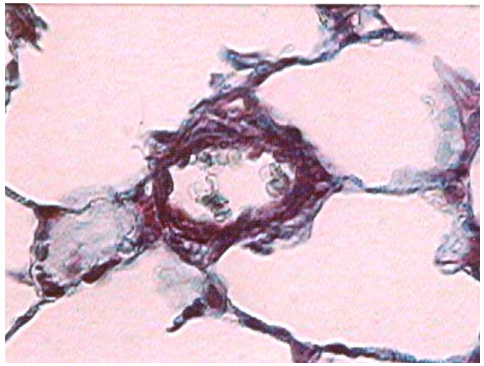


FIGURE 3. Normal human capillary network at 470× (original magnification). Note the high frequency of capillary anastomoses after vascular filling at 50 mm Hg silicone infusion pressure in this normal human lung.

FIGURE 5. Close-up view (original magnification × 190) of alveolar capillary network of Figure 4, shows absence of capillary anastomoses and rare arteriovenous communication. This correlated with markedly elevated hemodynamic pulmonary vascular resistance, 7-10 mm Hg min liter.

Zapol Chest 1977





Rabinovitch Am J Physiol 1979

WHITTENBERGER
JAP 1960

WEST
JAP 1964

RVP

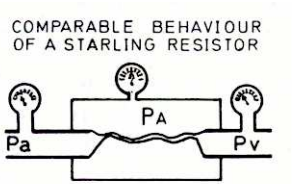
Zone 1

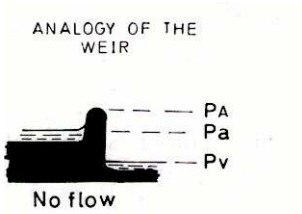
Zone 2

Zone 3

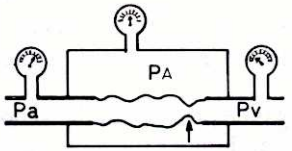
PTP
(cmH_2O)

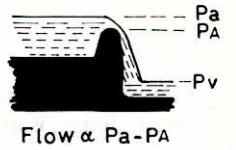
P_{ALV} > PAP > PVP

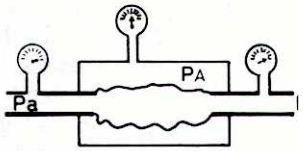


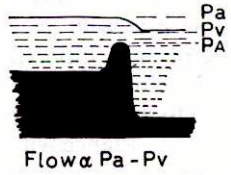


PAP > P_{ALV} > PVP









PAP > PVP > P_{ALV}

Vascular Obstruction Causes Pulmonary Hypertension in Severe Acute Respiratory Failure

Warren M. Zapol, Koichi Kobayashi, Michael T. Snider, Reginald Greene and Myron B. Laver

Chest 1977;71;306-307

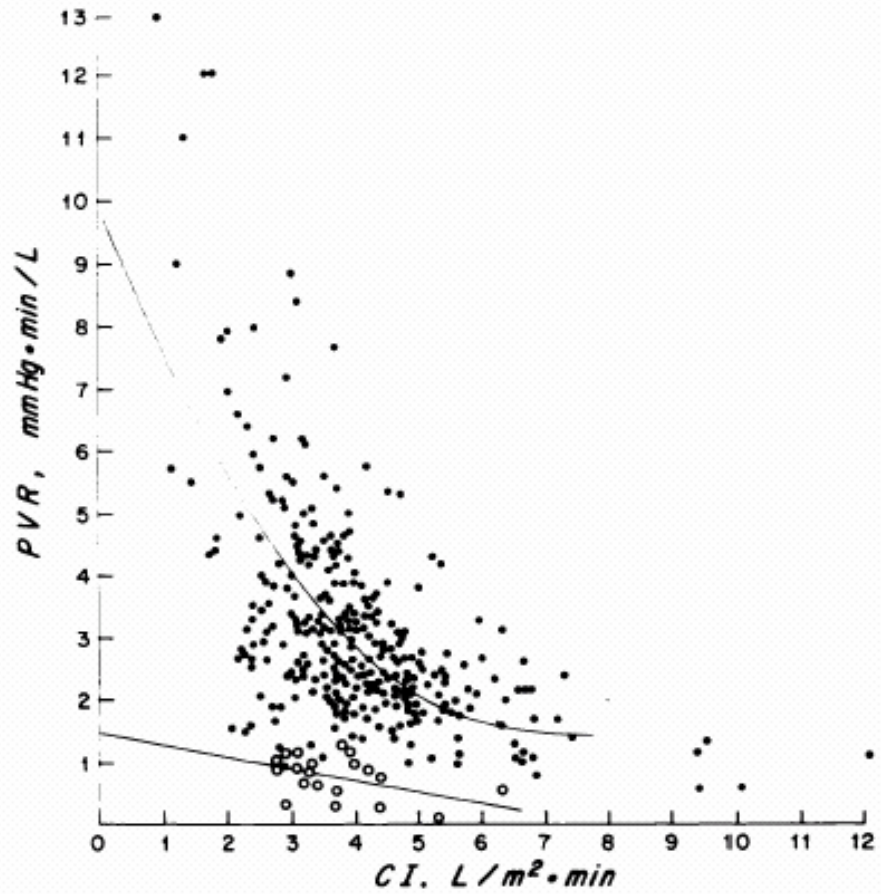
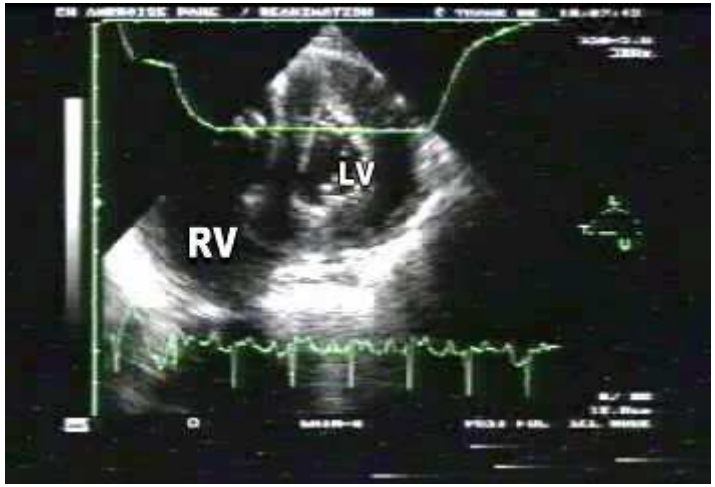


FIGURE 1. Statistical correlation of 290 measurements of PVR and CI on 16 patients with ARF. Normal data from Barratt-Boyes et al.[1] The groups are significantly different ($P<0.001$).

Surcharge diastolique



Surcharge systolique

F. Jardin
J.-L. Fellahi
A. Beauchet
A. Vieillard-Baron
Y. Loubières
B. Page

Improved prognosis of acute respiratory distress syndrome 15 years on

	"historical" ARDS (n = 33)	"recent" ARDS (n = 37)
Days on MV	14 ± 12	17 ± 14
TV (ml/kg)	13 ± 2	9 ± 2*
RR	16 ± 2	16 ± 2
FIO_2	0.59 ± 0.11	0.63 ± 0.13
EIP ($cm H_2O$)	39 ± 4	25 ± 4*
EEP ($cm H_2O$)	10 ± 4	6 ± 4*
PaO_2 (mm Hg)	66 ± 19	77 ± 22*
$PaCO_2$ (mm Hg)	36 ± 6	51 ± 10*
C_T (ml/cm H_2O)	31.4 ± 9.9	33.2 ± 12.6

CPA 61%
Jardin CCM 1985

CPA 25%
Vieillard-Baron CCM 2001

François Jardin
Antoine Vieillard-Baron

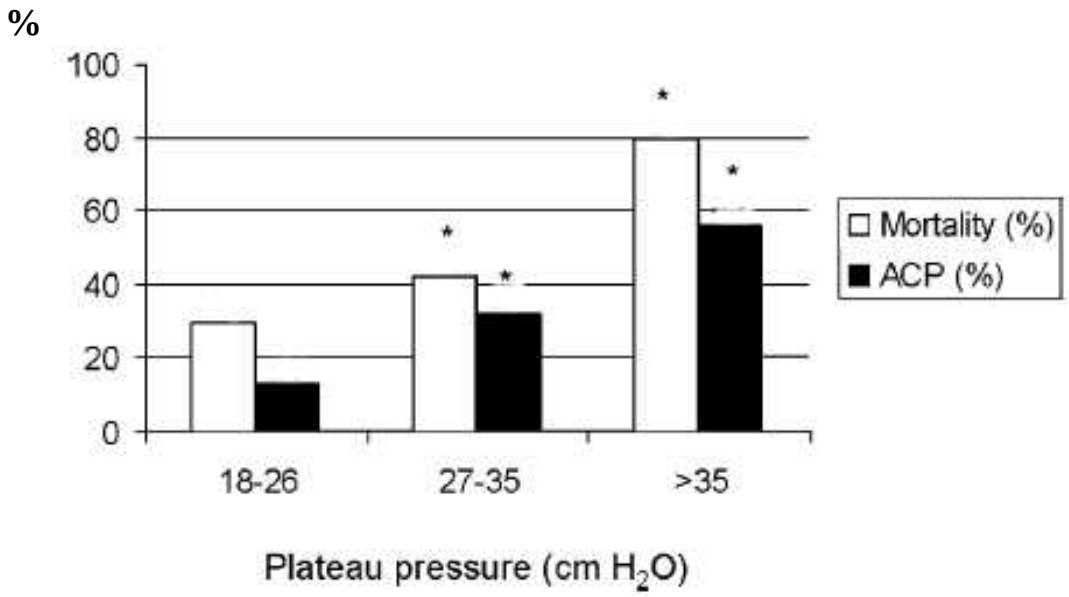
Is there a safe plateau pressure in ARDS? The right heart only knows

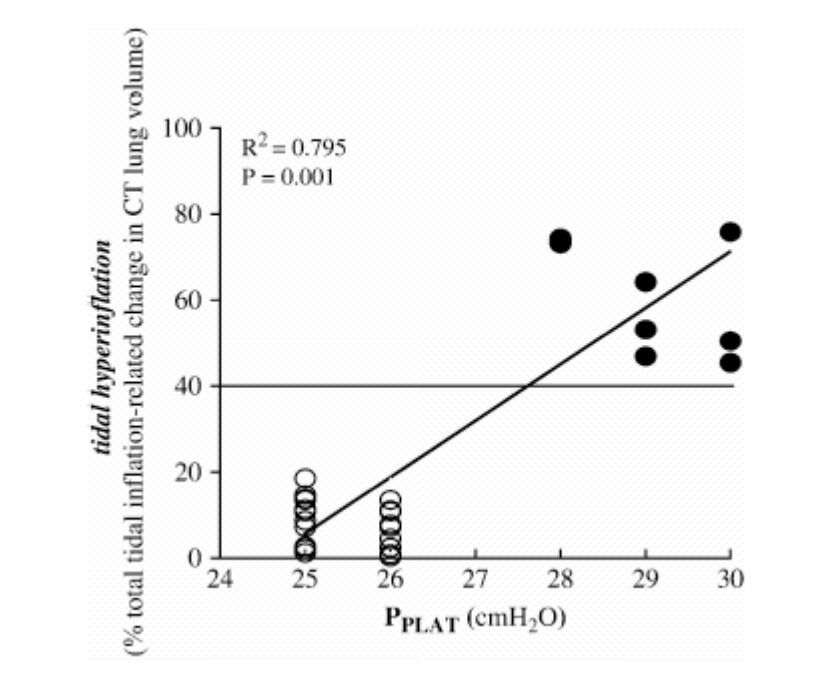
ICM 2007

1980-2006
352 SDRA avec ECHO

1980-1992
156 SDRA
Pas de limitation PP

1993-2006
196 SDRA
Low stretch strategy





Terragni et al. Am J Respir Crit Care Med 2007

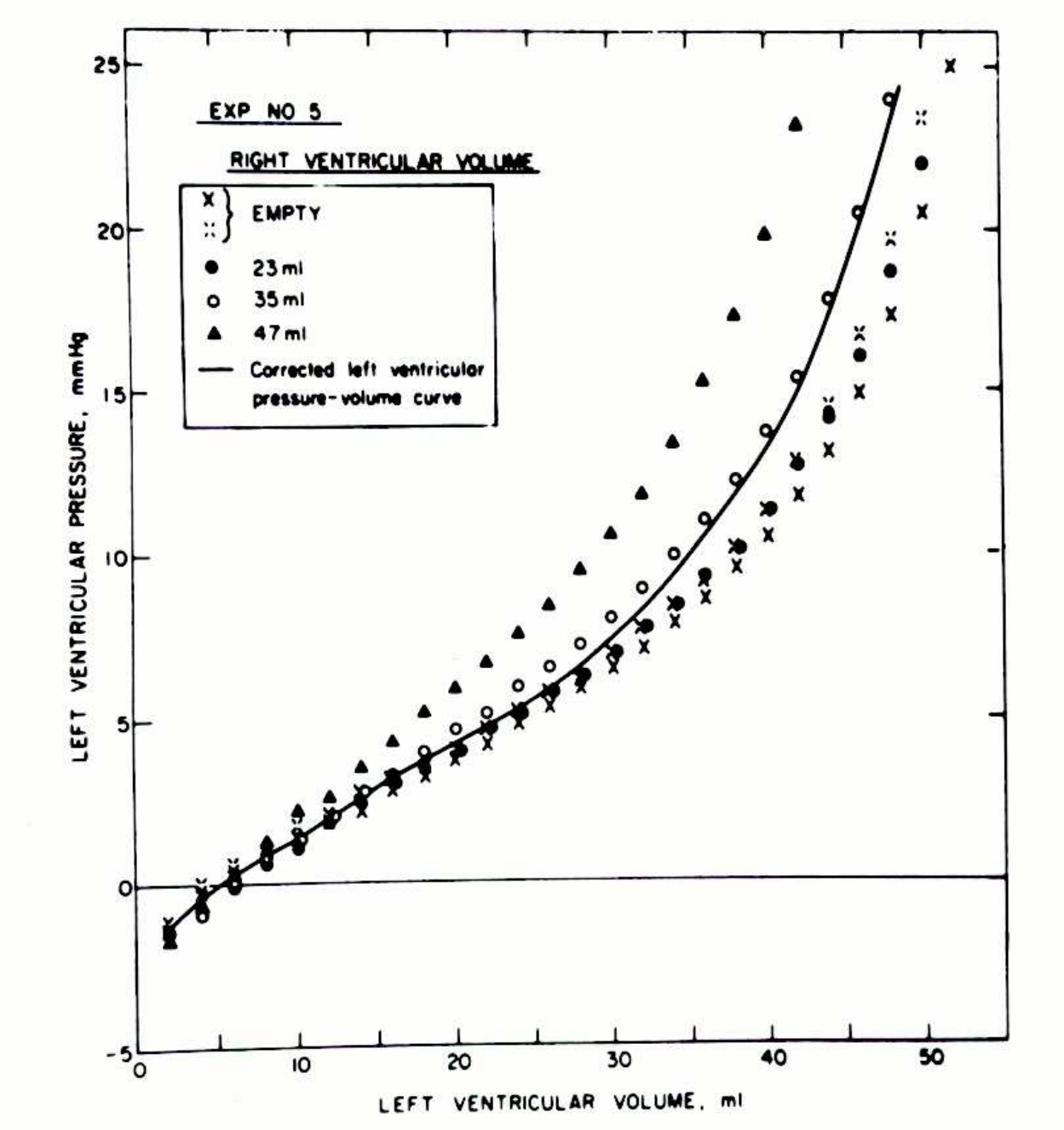
CONSEQUENCES DU CPA

SUR HEMODYNAMIQUE

Acute cor pulmonale in acute respiratory distress syndrome submitted to protective ventilation: Incidence, clinical implications, and prognosis

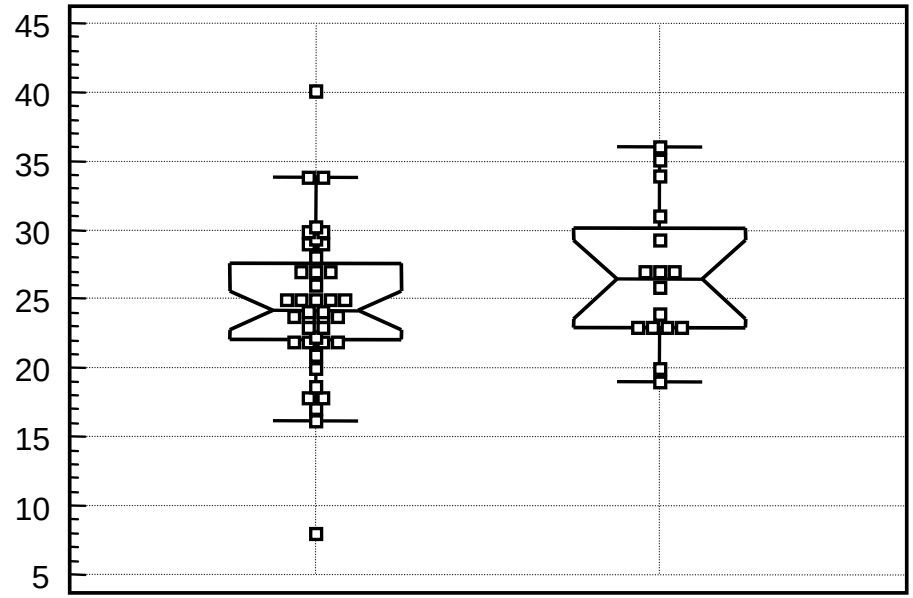
CCM 2001

	Group 1 (n = 56)	Group 2 (n = 19)
HR, beats/min	96 ± 19	112 ± 16[a]
SAP, mm Hg	114 ± 23	123 ± 25
CVP, mm Hg	12 ± 3	16 ± 3[a]
SI, cm^3/m^2	32 ± 9	25 ± 9[a]
CI, $L/min/m^2$	3.1 ± 0.9	2.7 ± 0.9
LVEDV, cm^3/m^2	60 ± 16	50 ± 15[a]
LVESV, cm^3/m^2	22 ± 10	24 ± 10
LVEF, %	53 ± 11	51 ± 16
E/A ratio, %	1.3 ± 0.4	0.8 ± 0.2[a]

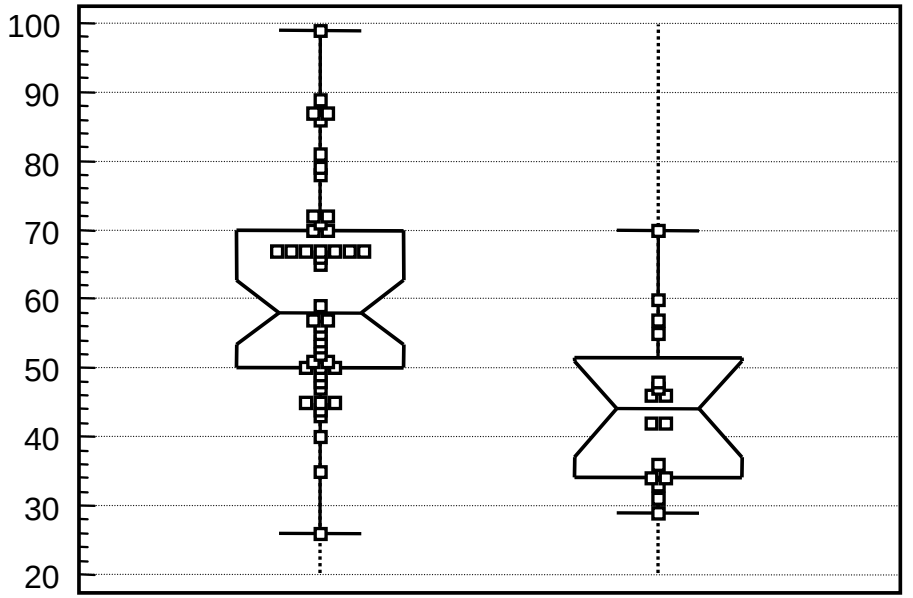


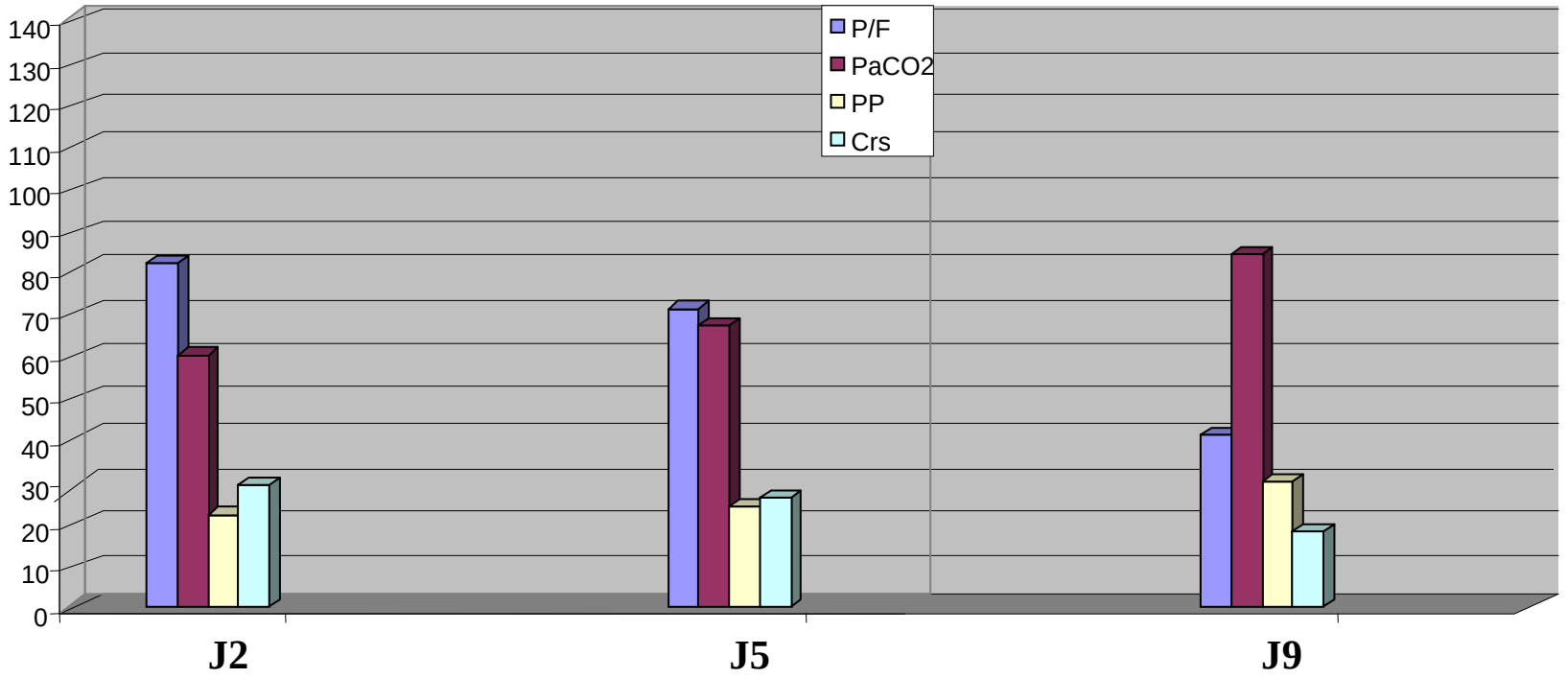
Taylor AJP 1967

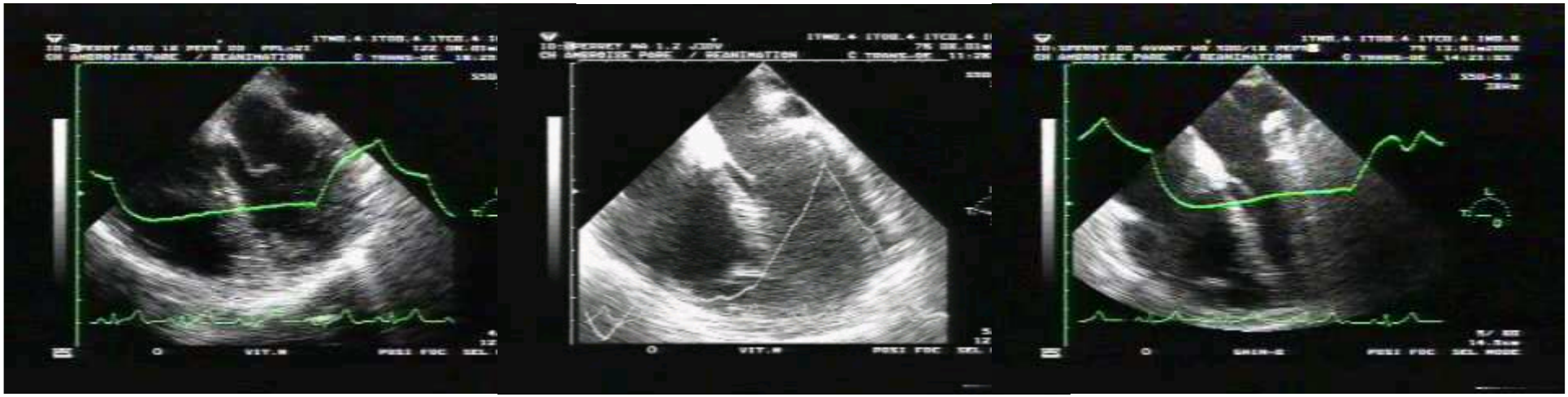
STD VD+VG
(cm^2)



VTDVG
(cm^3)







NE 0 NE 0.6 µg/kg/min NE 1.5 µg/kg/min

CONSEQUENCES DU CPA

SUR LE PRONOSTIC?

Acute cor pulmonale in acute respiratory distress syndrome submitted to protective ventilation: Incidence, clinical implications, and prognosis

CCM 2001

Prognosis Implications of ACP. The average mortality rate for the whole group was 32%. This mortality rate seemed not to be influenced by the presence of ACP, because both groups also had a 32% mortality rate. The subgroup of patients with "severe" ACP (four cases in whom RVEDA/LVEDA ratio was >1) had a mortality rate of 25%.

Acute cor pulmonale in acute respiratory distress syndrome: A dreaded complication of the past?

Zapol CCM 2001

		Paramètres	Odds ratio	PP, PEEP
Observational studies	**Early Predictive Factors of Survival in the Acute Respiratory Distress Syndrome** A Multivariate Analysis MEHRAN MONCHI, FLORENCE BELLENFANT, ALAIN CARIOU, LUC-MARIE JOLY, DOMINIQUE THEBERT, IVAN LAURENT, JEAN-FRANÇOIS DHAINAUT, and FABRICE BRUNET **AJRCCM 1998**	**Pra > Ppao**	**5.1 [1.5-17.1]**	**PP 31 [27-38]** **PEEP 8 [6-11]**
	Intensive Care Med (1998) 24: 1018–1028 © Springer-Verlag 1998 ORIGINAL P. Squara J.-F.A. Dhainaut A. Artigas J. Carlet and the European Collaborative ARDS Working Group **Hemodynamic profile in severe ARDS: results of the European Collaborative ARDS Study**	**RVSW/LVSW (%)**	**[10-35]**	**P_{alv} 23 ± 8** **PEEP 8 ± 4**
Intervention study	Acute cor pulmonale in acute respiratory distress syndrome submitted to protective ventilation: Incidence, clinical implications, and prognosis Antoine Vieillard-Baron, MD; Jean-Marie Schmitt, MD; Roch Augarde, MD; J. L. Fellahi, MD; Sebastien Prin, MD; Bernard Page, MD; Alain Beauchet, MD; François Jardin, MD **CCM 2001**	**CPA ECHO**	**NS**	**PP<27** **PEEP 7 ± 3** **Prone position**

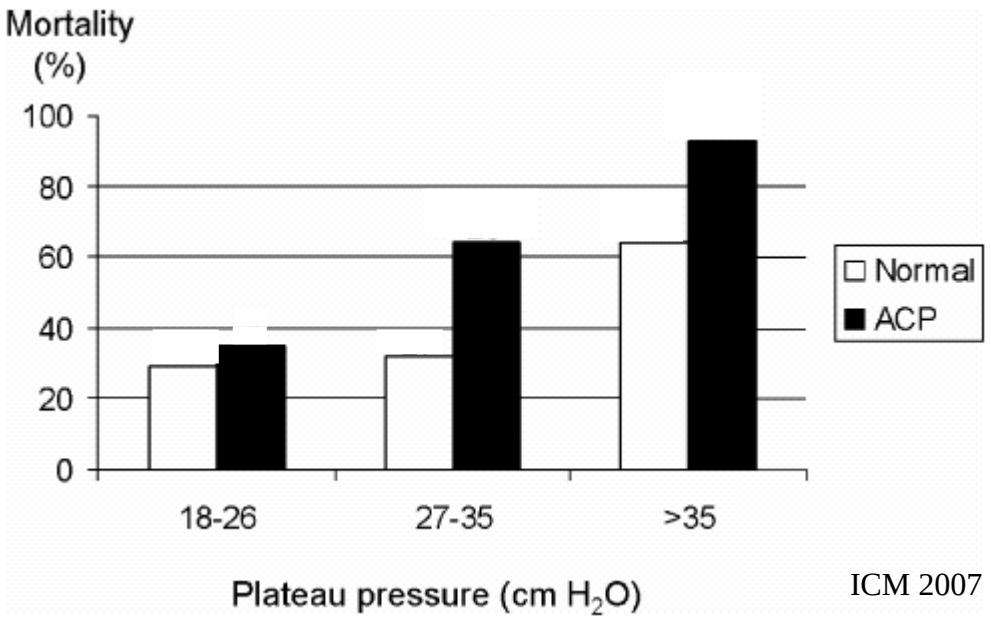
David Osman
Xavier Monnet
Vincent Castelain
Nadia Anguel
Josiane Warszawski
Jean-Louis Teboul
Christian Richard
for the French Pulmonary
Artery Catheter Study Group

Incidence and prognostic value of right ventricular failure in acute respiratory distress syndrome

ICM 2008

145 SDRA

Model B			
	Adjusted HR	95%CI	*P*
MPAP	1.14	1.06–1.23	**<0.01**
CVP > PAOP	4.65	1.52–14.28	**<0.01**
SVI	0.96	0.91–1.00	0.05
Age	1.02	0.99–1.06	0.09
Murray score	4.22	0.9–25.2	0.06
PaO_2/FiO_2	0.97	0.95–0.99	**<0.01**
pHa	0.001	0.00–0.20	**<0.01**
Cst	0.94	0.90–0.99	**<0.05**
MAP	0.95	0.91–0.98	**<0.01**
SvO_2	0.92	0.87–0.97	**<0.01**


Mortality
(%)
100
80
60
40
20
0
18-26
27-35
>35
Plateau pressure (cm H_2O)
Normal
ACP

ICM 2007

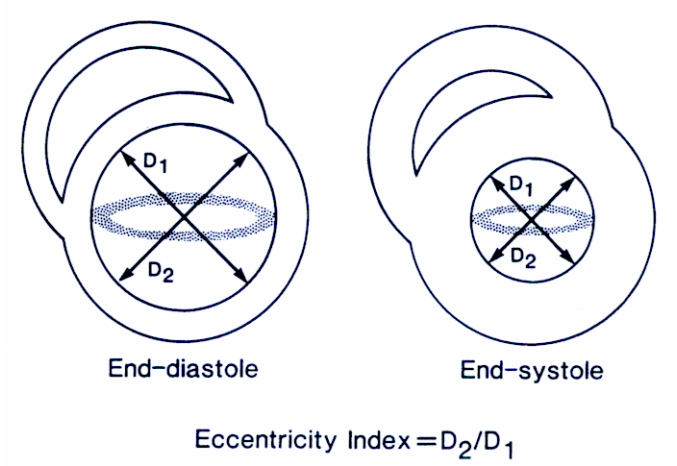
EN PRATIQUE CLINIQUE

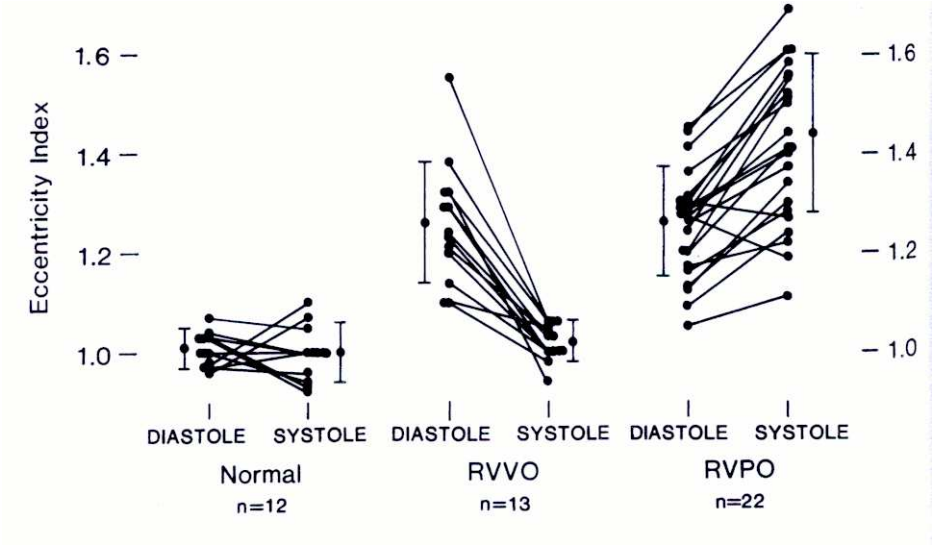
ADAPTER LES REGLAGES DU VENTILATEUR A LA FONCTION VD?

Impact of Acute Permissive Hypercapnia and Augmented Positive End-Expiratory Pressure at Constant Plateau Pressure on Right Ventricle Function in Severe Acute Respiratory Distress Syndrome

	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]*


D1
D2
End-diastole
D1
D2
End-systole
Eccentricity Index = D2/D1


Eccentricity Index
1.6
1.4
1.2
1.0
DIASTOLE
SYSTOLE
Normal
n=12
DIASTOLE
SYSTOLE
RVVO
n=13
DIASTOLE
SYSTOLE
RVPO
n=22

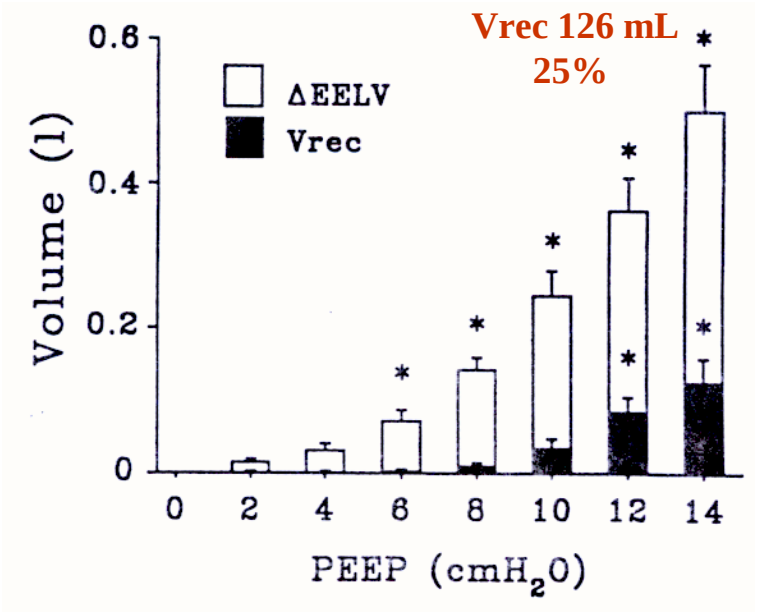
PEEP 7 PP 27

IS_{VD} 23 ml/m²
PAS 135 mmHg
FC 100/mn

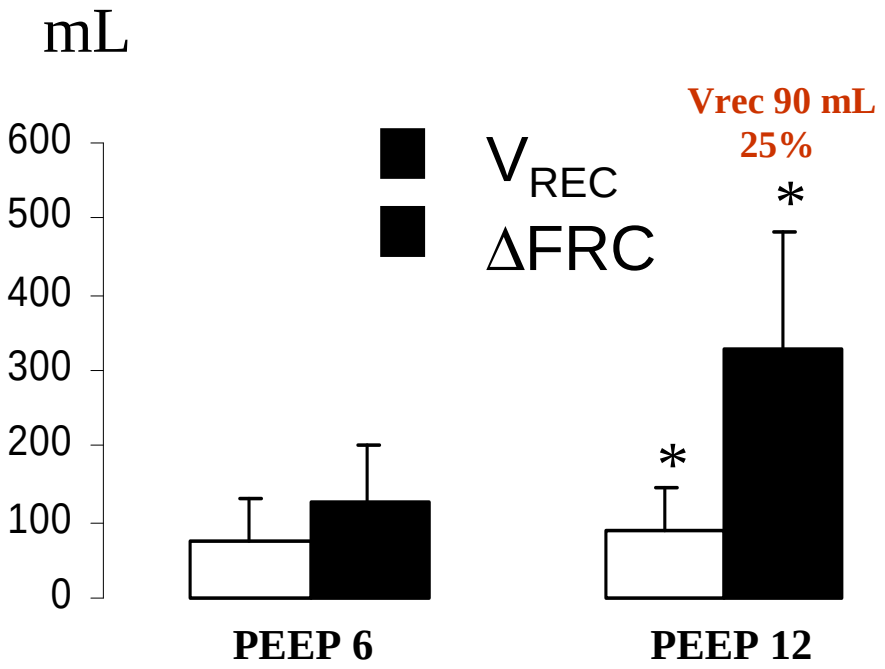
PEEP 14 PP 27

IS_{VD} 12 ml/m²
PAS 115 mmHg
FC 121/mn

EFFET DE LA PEEP?



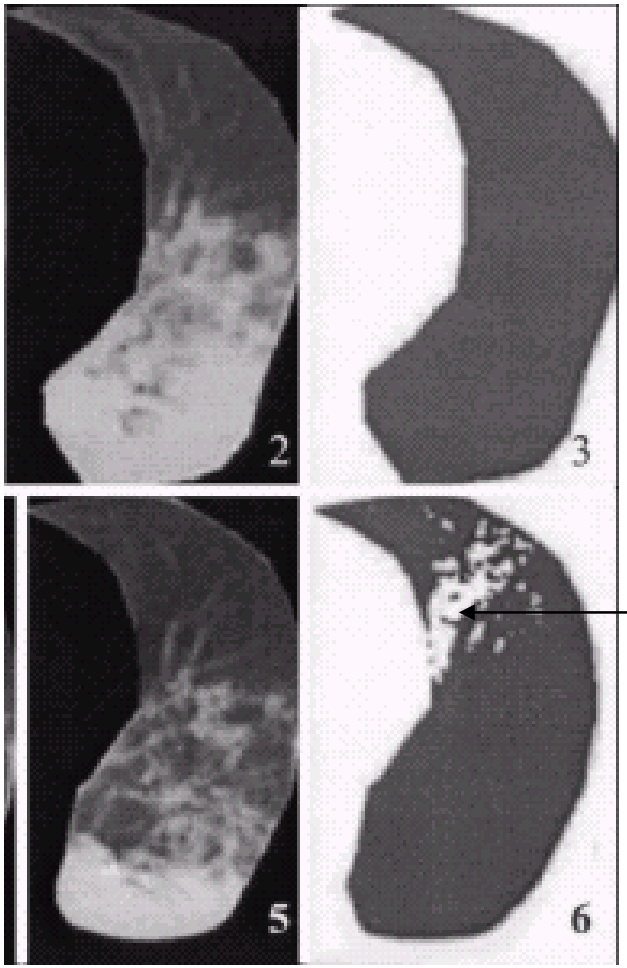
Valta JCC 1993



Vieillard-Baron ICM 2003

ZEEP

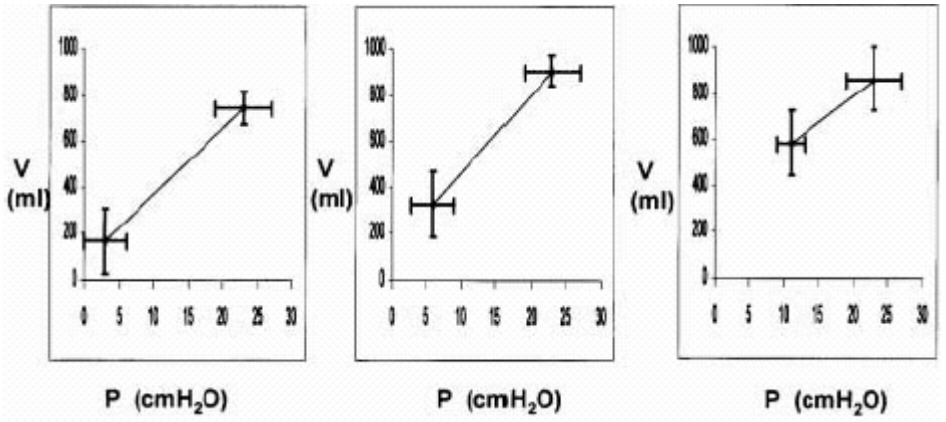
PEEP 15



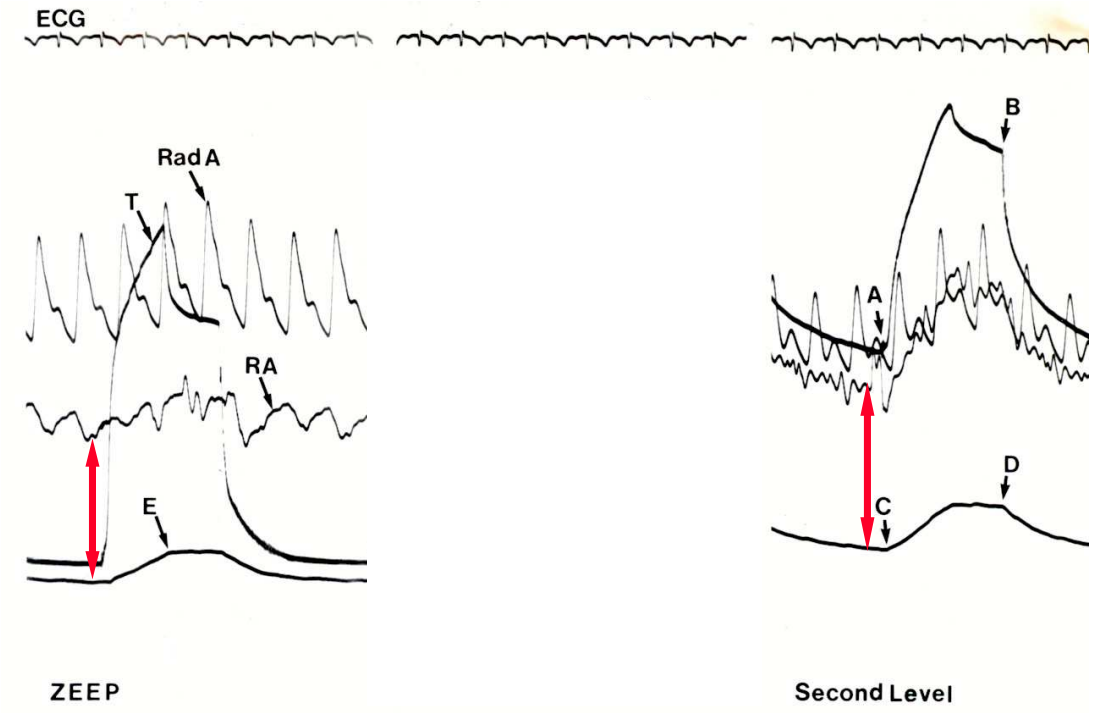
Overdistension
Anterior area

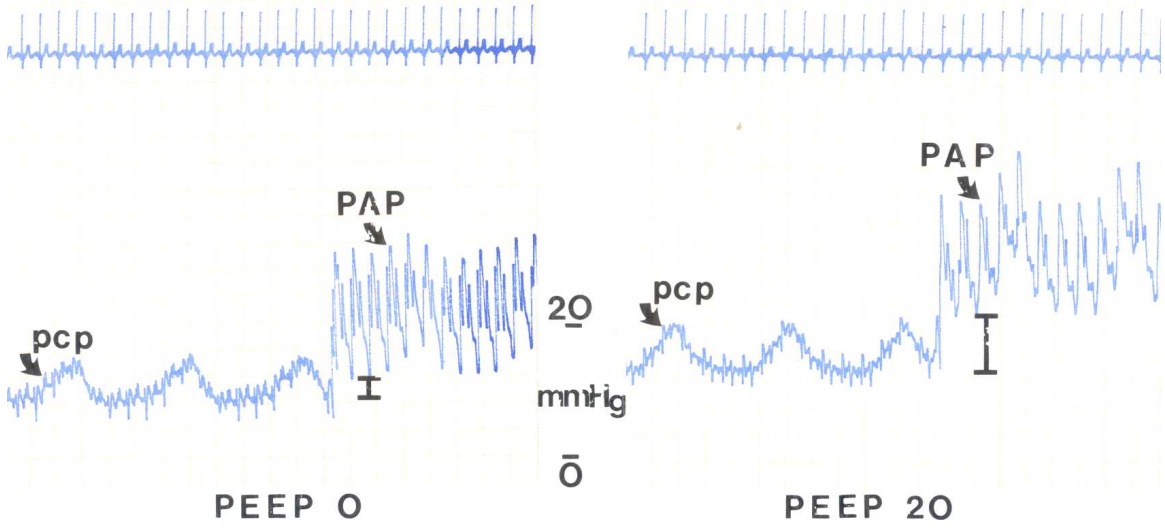
Rouby CCM 2004

ZEEP **PEEP 6 ± 2** **PEEP 11 ± 4**



Vieillard-Baron AJRCCM 2002


ECG
Rad A
T
RA
E
ZEEP
B
A
C
D
Second Level

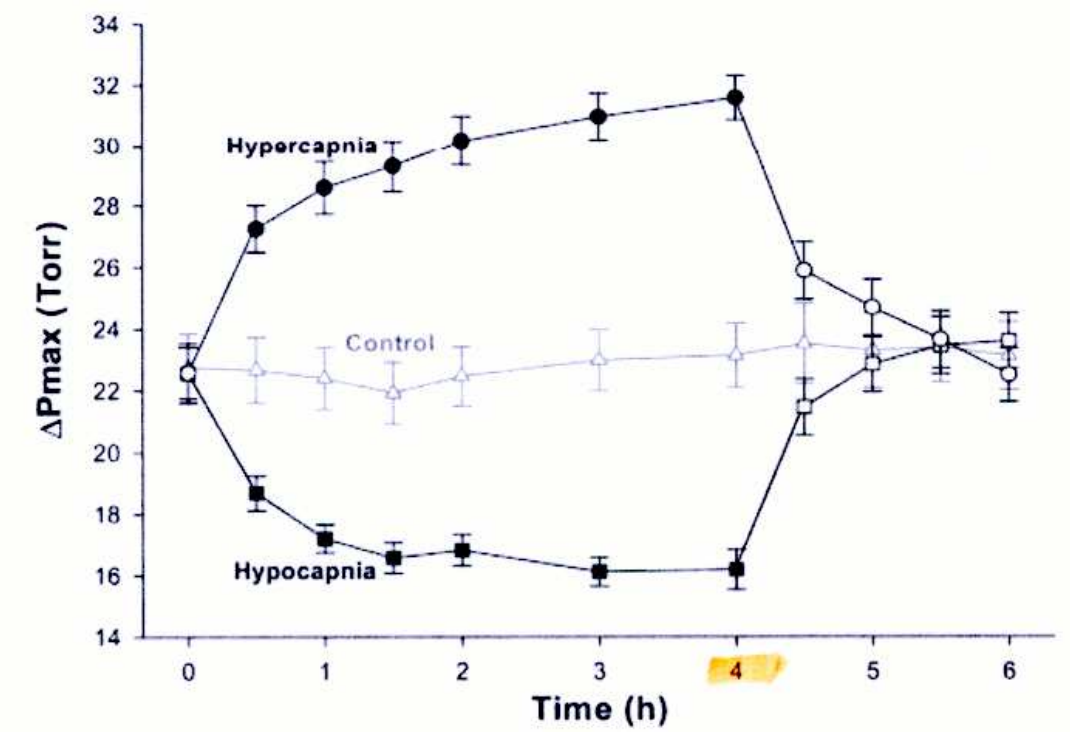

PAP
pcp
PEEP 0
20
mmHg
0
PAP
pcp
PEEP 20

EFFET DE L'HYPERCAPNIE?

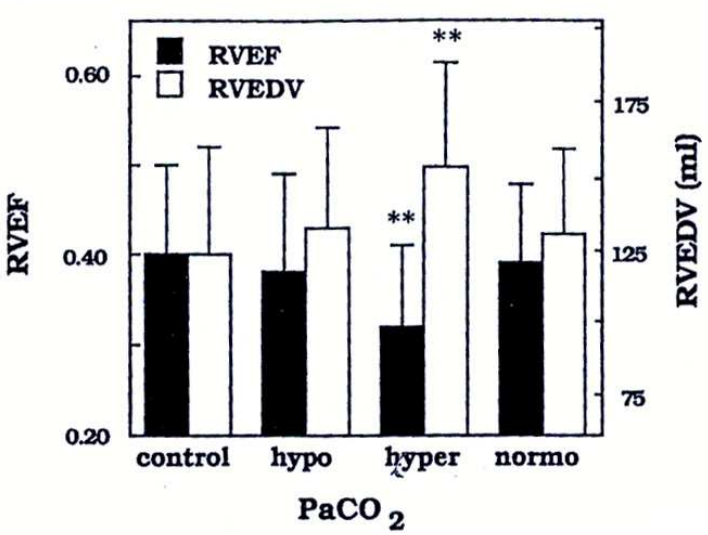
Acute cor pulmonale in acute respiratory distress syndrome submitted to protective ventilation: Incidence, clinical implications, and prognosis

CCM 2001

	Group 1	Group 2	Univariate *p*	Multivariate *p*	OR (CI)
Age, yrs	56 ± 16	52 ± 17	NS		
SAPS II	55 ± 17	49 ± 16	NS		
LODS	10.1 ± 4	9.9 ± 3.4	NS		
Pao_2/Fio_2, mm Hg	115 ± 32	87 ± 24	.001	NS	
$Paco_2$, mm Hg	47 ± 9	64 ± 12	.000003	.0001	1.15 (1.05–1.25)
CT, mL/cm H_2O	37 ± 11	31 ± 12	NS		
TV, mL/kg	8 ± 1	8 ± 1	NS		
Plateau, cm H_2O	23 ± 5	27 ± 4	.004	NS	
PEEP, cm H_2O	6 ± 3	9 ± 4	.0003	NS	
Fluid balance, mL	2300 ± 2400	3200 ± 2000	NS		



Balanos J Appl Physiol 2003

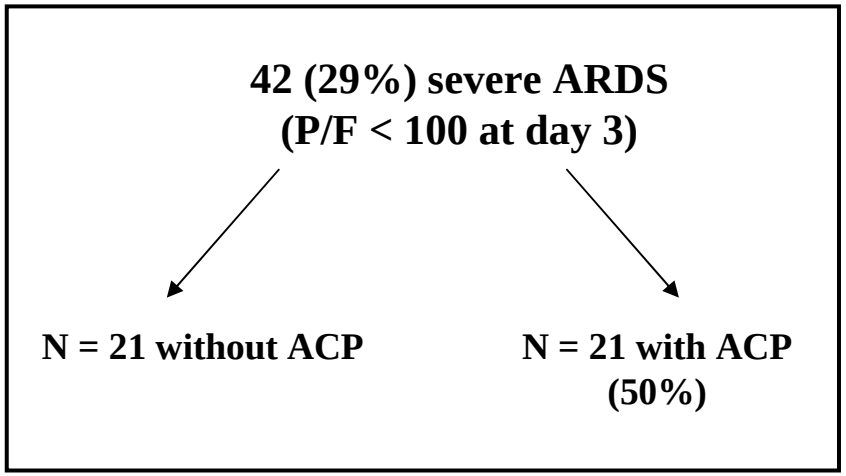


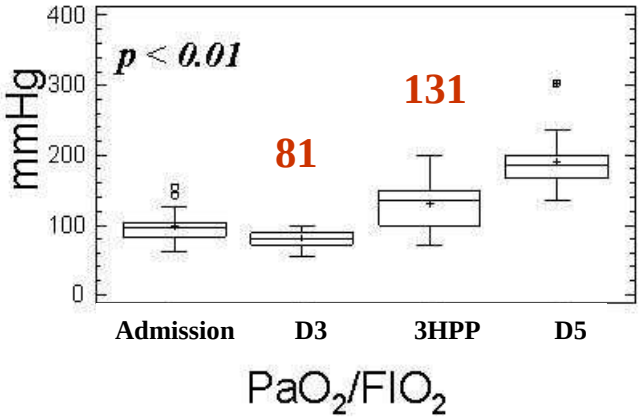
Viitanen Anesthesiology 1990

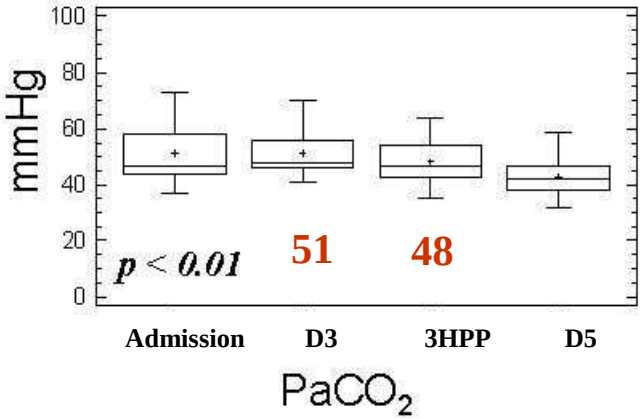
Prone Positioning Unloads the Right Ventricle in Severe ARDS*

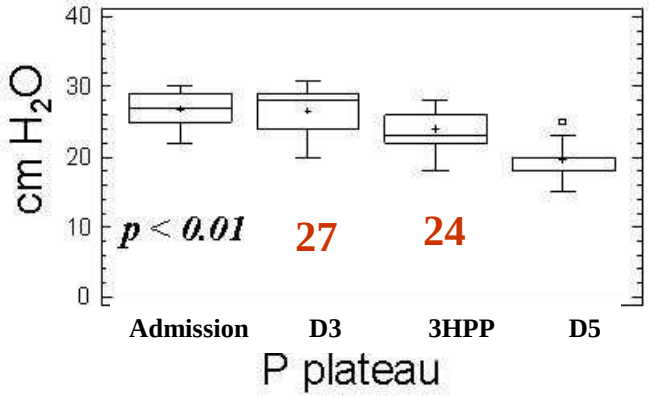
Antoine Vieillard-Baron, MD; Cyril Charron, MD; Vincent Caille, MD; Guillaume Belliard, MD; Bernard Page, MD; and François Jardin, MD

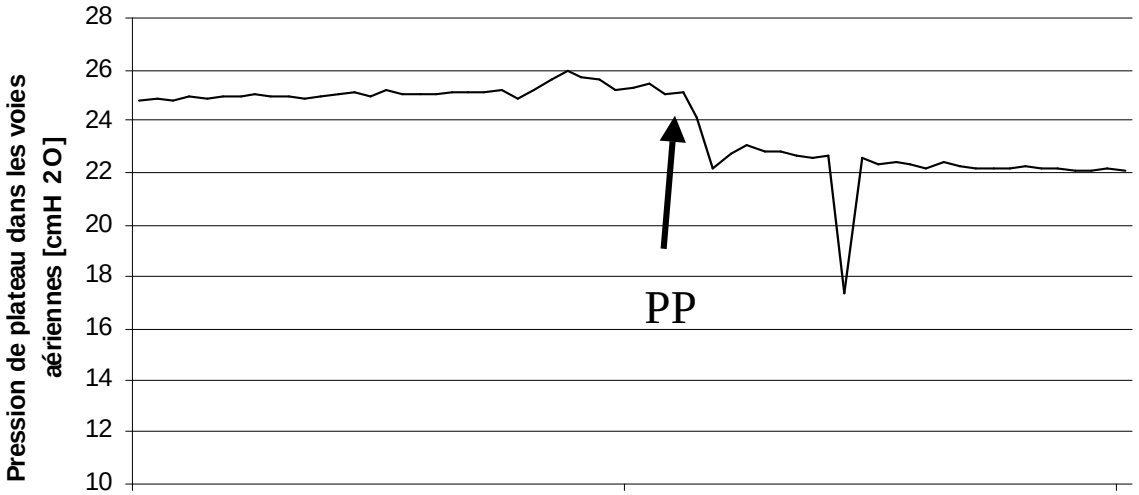
Chest 2007

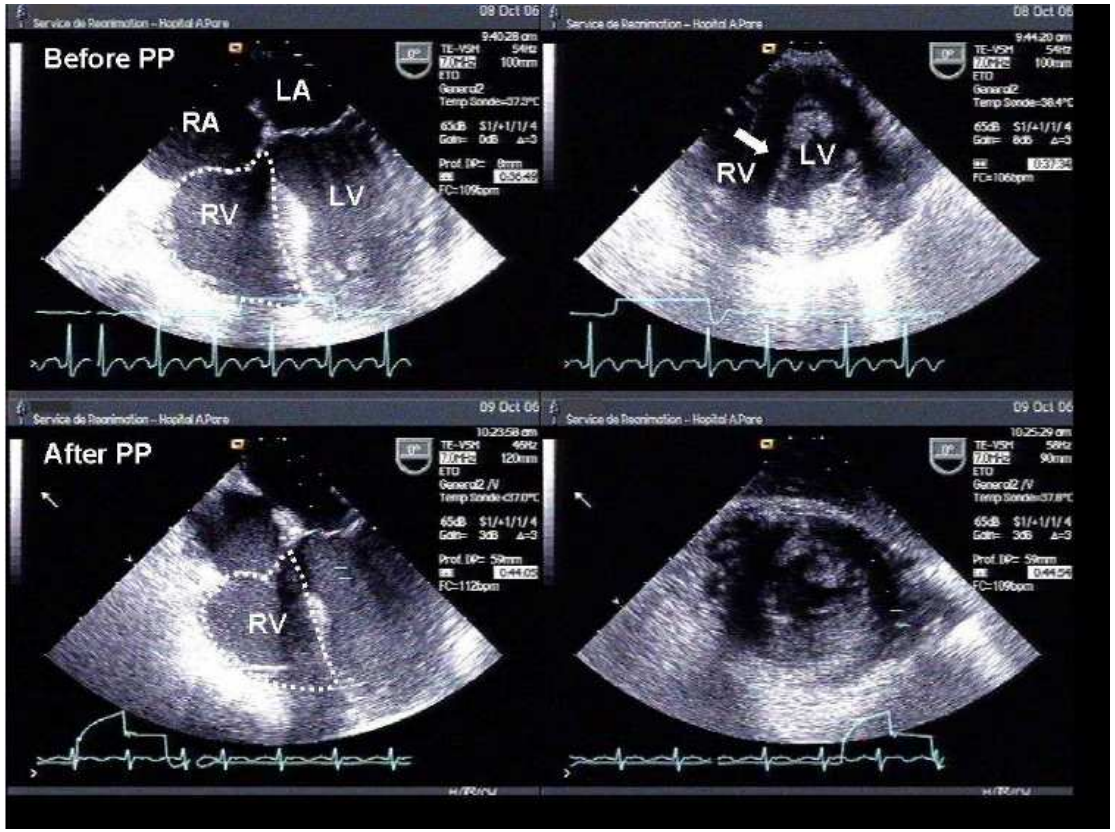



400
300
200
100
0
mmHg
p < 0.01
81
131
Admission
D3
3HPP
D5
PaO2/FIO2


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


Pression de plateau dans les voies aériennes [cmH 2O]
28
26
24
22
20
18
16
14
12
10
PP


Before PP
LA
RA
RV
LV
RV
LV
After PP
RV

CONCLUSION

- Le SDRA est une maladie de la circulation pulmonaire
  - Remodelage vasculaire
  - Effet de la ventilation mécanique
- La défaillance du ventricule droit est un facteur pronostic majeur si il n’est pas pris en compte
- Une surveillance de la fonction du VD est indispensable et maintenant recommandée
- Les réglages du ventilateur doivent tenir compte de la défaillance du ventricule droit
  - Diminuer Pplateau
  - Limiter la PEEP
  - Limiter la PaCO2
  - Décubitus ventral

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