

Sistema Sanitario Regione Liguria

DI GENOVA

The PROBESE Trial

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Conflicts of Interest

I declare **NO** conflicts of interest





Petrini F et al. Minerva Anestesiol 2016 Dec;82(12):1314-1335

PROtective VEntilation NETwork

PR©TECTIVE VENTILATION NETWORK











- Multicenter observational studies
- Randomized controlled trials
- ✤ Meta-analysis
- Health economy analysis
- Translation and education



Sometimes you need to fightbut always with "elegance"



Agenda

- Postoperative pulmonary complications
- Physiological changes
- Protective mechanical ventilation
- Mechanical ventilation "in real life"
- Current reccomendations
- The PROBESE Trial



PPCs are more frequent when BMI > 40 Kg/m²

Ball L et al. Br J Anaesth. 2018 Oct;121(4):899-908

Class I: 30.0 to 34.9 kg/m² - Class II; 35 to 39.9 kg/m² - Class III; \geq 40 kg/m²



PPCs (mild or severe) increase the LOS

Ball L et al. Br J Anaesth. 2018 Oct;121(4):899-908

Class I: 30.0 to 34.9 kg/m² - Class II; 35 to 39.9 kg/m² - Class III; \geq 40 kg/m²



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- Current reccoemndations
- > The PROBESE Trial
- Conclusions

Prof Hedensierna G., University of Uppsala, Sweden He discovered atelectasis during anesthesia and mechanical ventilation Effects of Anesthesia on Lung Morphology Reinius H et al. Anesthesiology. 2009 Nov;111(5):979-87 Pelosi P et al. Best Pract Res Clin Anaesthesiol. 2010 Jun;24(2):211-25 Pompilio CE et al. Curr Atheroscler Rep. 2016 Sep;18(9):55 Imber DAE et al. Respir Care. 2016 Dec;61(12):1681-1692



Atelectasis and Obesity

Rothen HU et al. Br J Anaesth 1993, 71:788-95



Obesity increases postoperative atelectasis Eichenberger et al. Anesth Analg 2002; 95: 1788-1795



Pulmonary atelectasis: a pathogenic perioperative entity !

Duggan M, Kavanagh BP, Anesthesiology 2005; 102: 838-54



Atelectasis and PPCs

Bonatti G et al. Expert Rev Respir Med. 2019 May;13(5):471-479



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Protect the Lungs during Abdominal Surgery

It May Change the Postoperative Outcome

Vidal Melo M.F., Eikermann M. Anesthesiology 2013; 118:1254-7 Severgnini P. et al. Anesthesiology. 2013 Jun;118(6):1307-21



Individualized PEEP to keep the lung open in obese and non obese patients Pereira SM et al. Anesthesiology. 2018 Dec;129(6):1070-1081



Individualized PEEP to keep the lung open is different among obese and non obese patients Pereira SM et al. Anesthesiology. 2018 Dec;129(6):1070-1081



Individualized PEEP reduces $\triangle P$ more in obese than in non obese patients

Pereira SM et al. Anesthesiology. 2018 Dec;129(6):1070-1081



Individualized PEEP to keep the lung open reduces postoperative atelectasis Pereira SM et al. Anesthesiology. 2018 Dec;129(6):1070-1081



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V_T (ml/PBW or IBW) in obese patients

Ball L et al. Br J Anaesth. 2018 Oct;121(4):899-908

Class I: 30.0 to 34.9 kg/m² - Class II; 35 to 39.9 kg/m² - Class III; \geq 40 kg/m²



PEEP in obese patients

Ball L et al. Br J Anaesth. 2018 Oct;121(4):899-908

Class I: 30.0 to 34.9 kg/m² - Class II; 35 to 39.9 kg/m² - Class III; \geq 40 kg/m²



Recruitment maneuvre by bag squeezing increases PPCs in obese patients

Ball L et al. Br J Anaesth. 2018 Oct;121(4):899-908

2012 obese patients from 135 hospitals across 29 countries in Europe, North America, North Africa & Middle East

Variable	All PPCs OR (95% CI), p value
Age	1.02 [1.01 - 1.03], 0.001
Duration of Anaesthesia (h)	1.38 [1.25 - 1.52], <0.001
Peak Pressure (cmH ₂ O)	1.07 [1.03 - 1.11], <0.001
Obstructive sleep apnoeas	2.34 [1.32 - 4.14], 0.004
Routine Recruitment Manoeuvres	
Not Performed	1 (Reference)
Ventilator	0.49 [0.16 - 1.49], 0.209
Bag Squeezing	2.06 [1.14 - 3.73], 0.017

Intraoperative hemodynamic events are more frequent than respiratory events in obese patients Ball L et al. Br J Anaesth. 2018 Oct;121(4):899-908

Class I: 30.0 to 34.9 kg/m² - Class II; 35 to 39.9 kg/m² - Class III; \geq 40 kg/m²

PEEP 4 (0-5) cm H ₂ O	Non Obese (6736)	Class I (1315)	Class II (449)	Class III (248)
Desaturation	3.3%	5.7%	7.3%	14.9%
- Recruitment	2.5%	5.5%	5.1%	11.2%
- Increased FiO2	0.8%	0.2%	2.1%	3.7%
Hypotension	23.7%	24.9%	27.2%	27.4%
- Vasoactive drugs	18.5%	23.2%	23.4%	27.0%
- Fluids	5.2%	1.7%	3.8%	0.4%

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Prevention and care of respiratory failure in obese patients

Pepin JL, Jaber S et al. Lancet Respir Med 2016;4: 407–18

From the start of mechanical ventilation and during the whole period of ventilation, it's preferable to implement:

1. Which ventilatory mode? \longrightarrow **Pressure or volume**

2. Which Tidal Volume?

3. Which PEEP?

8 ml/kg PBW

4. Recruitment maneuvres?

10 cmH₂O or higher

Yes (combined with PEEP)

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Intraoperative PEEP in obese patients ?











JAMA

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effect of Intraoperative High Positive End-Expiratory Pressure (PEEP) With Recruitment Maneuvers vs Low PEEP on Postoperative Pulmonary Complications in Obese Patients A Randomized Clinical Trial

Writing Committee for the PROBESE Collaborative Group of the PROtective VEntilation Network (PROVEnet) for the Clinical Trial Network of the European Society of Anaesthesiology

IMPORTANCE An intraoperative higher level of positive end-expiratory positive pressure (PEEP) with alveolar recruitment maneuvers improves respiratory function in obese patients undergoing surgery, but the effect on clinical outcomes is uncertain.

OBJECTIVE To determine whether a higher level of PEEP with alveolar recruitment maneuvers decreases postoperative pulmonary complications in obese patients undergoing surgery compared with a lower level of PEEP.

DESIGN. SETTING. AND PARTICIPANTS Randomized clinical trial of 2013 adults with body mass indices of 35 or greater and substantial risk for postoperative pulmonary complications who were undergoing noncardiac, nonneurological surgery under general anesthesia. The trial was conducted at 77 sites in 23 countries from July 2014-February 2018; final follow-up: May 2018.

INTERVENTIONS Patients were randomized to the high level of PEEP group (n = 989), consisting of a PEEP level of 12 cm H₂O with alveolar recruitment maneuvers (a stepwise increase of tidal volume and eventually PEEP) or to the low level of PEEP group (n = 987), consisting of a PEEP level of 4 cm H₂O. All patients received volume-controlled ventilation with a tidal volume of 7 mL/kg of predicted body weight.

MAIN OUTCOMES AND MEASURES The primary outcome was a composite of pulmonary complications within the first 5 postoperative days, including respiratory failure, acute respiratory distress syndrome, bronchospasm, new pulmonary infiltrates, pulmonary infection, aspiration pneumonitis, pleural effusion, atelectasis, cardiopulmonary edema, and pneumothorax. Among the 9 prespecified secondary outcomes, 3 were intraoperative complications, including hypoxemia (oxygen desaturation with Spo₂ =592% for >1 minute).

RESULTS Among 2013 adults who were randomized, 1976 (98.2%) completed the trial (mean age, 48.8 years; 1881 (69.9%) women: 1778 (90.1%) underwent abdominal operations). In the intention-to-treat analysis, the primary outcome occurred in 211 of 989 patients (21.3%) in the high level of PEEP group compared with 233 of 987 patients (23.6%) in the low level of PEEP group (difference, -2.3% (95% CI, -5.9% to 14%); risk ratio, 0.93 (95% CI, 0.83 to 1.04]; P = .23). Among the 9 prespecified secondary outcomes, 6 were not significantly different between the high and low level of PEEP groups, and 3 were significantly different, including fewer patients with hypoxemia (5.0% in the high level of PEEP group, s1.6% in the low level of PEEP group, difference, -8.6% (95% CI, -1.1% to 6.1%); P < .00).

CONCLUSIONS AND RELEVANCE Among obese patients undergoing surgery under general anesthesia, an intraoperative mechanical ventilation strategy with a higher level of PEEP and alveolar recruitment maneuvers, compared with a strategy with a lower level of PEEP, did not reduce postoperative pulmonary complications.

TRIAL REGISTRATION ClinicalTrials.gov Identifier: NCTO2148692

Author and Group Information: The PROBESE Collaborative Group authors and collaborators appear at the end of this article.

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Visual Abstract
Editorial
Supplemental content

JAMA Network

JAMA. 2019 Jun 18;321(23):2292-2305



An intraoperative mechanical ventilation strategy with high PEEP and alveolar recruitment manoeuvres reduces the incidence of PPC compared with low PEEP without alveolar recruitment manoeuvres in obese surgical patients







Patients

Inclusion criteria

BMI ≥ 35 kg/m²; elective surgery with expected >2h duration under general anaesthesia; intermediate to high risk of PPC (ARISCAT score)

Exclusion criteria

age < 18 years; previous lung surgery; mechanical ventilation > 30 min in the preceding 30 days; chemo/radiotherapy in the preceding 2 months; cardiac or neurological surgery; intraoperative one-lung ventilation; planned re-intubation; prone or lateral decubitus position; participation in another RCT







Interventions

Volume controlled ventilation with V_T of 7 mL/kg PBW

High PEEP group

- \circ PEEP level of 12 cmH₂O
- recruitment manoeuvres after intubation, disconnection, hourly, at end of surgery
- rescue for hypoxemia: increase of PEEP preferred (recruitment)

Low PEEP group

- \circ PEEP level of 4 cmH₂O
- rescue for hypoxemia: increase of FIO₂ preferred (increase PEEP)







Methods - Recruitment manoeuvre









Methods – Rescue strategies

If intraoperative hypoxemia,

defined as oxygen saturation \leq 92%, develops:

	Lower PEEP			Hig	her PEEP	
Step	FiO ₂	PEEP [cmH ₂ O]		FiO ₂	PEEP [cmH2O]
1	0.5	4		0.4	14	(+RM)
2	0.6	4		0.4	16	(+RM)
3	0.7	4		0.4	18	(+RM)
4	0.8	4		0.5	18	
5	0.9	4		0.6	18	
6	1.0	4		0.7	18	
7	1.0	5		0.8	18	
8	1.0	6		0.9	18	
9	1.0	7	(+RM)	1.0	18	
10				1.0	20	(+RM)






Outcomes

Primary outcome

 composite PPC defined as an adverse pulmonary event within 5d

(mild, moderate, severe respiratory failure; ARDS; bronchospasm; new pulmonary infiltrates; pulmonary infection; aspiration pneumonitis; pleural effusion; atelectasis; cardiopulmonary oedema; pneumothorax)







Outcomes

Secondary outcomes

- \circ composite of severe PPC
- postoperative extra-pulmonary complications
- \circ impaired wound healing
- \circ unexpected ICU admission
- hospital-free days at 90d
- intraoperative hypoxemia
- intraoperative hypotension
- intraoperative bradycardia
- in-hospital mortality







Outcomes

Post hoc outcomes

- 5d mortality
- $\circ\,$ need for rescue due to desaturation
- $\circ\,$ need for vasoactive drugs







Statistics

Sample size calculations

- 20% incidence in low
 PEEP group (adjusted after 600 cases)
- o relative risk of 0.75
- 80% power, two-sided alpha-level of 0.05
- Interim analyses at 50%, 75% and 100% (nonbinding sequential design)

estimated 5% dropout



PR TFCTIVE

VFΝΤΙΙ ΔΤΙΟΝ

IFTWORK





PROBESE world map

From July 2014 through February 2018



77 participation sites
23 countries
> 315 collaborators

CONSORT









Baseline characteristics

Characteristic	High PEEP	Low PEEP		
	(n = 989)	(n = 987)		
Age – years, mean (SD)	48.6 (13.8)	48.9 (13.3)		
Female patients, No. (%)	694 (70.1)	687 (69.6)		
$BMI - kg/m^2$, mean (SD)	44.0 (7.4)	43.5 (7.1)		
35–40, No. (%)	337 (34.1)	378 (38.3)		
>40, No. (%)	652 (65.9)	609 (61.7)		
ARISCAT score ^a , mean (SD)	37.2 (7.6)	37.2 (7.1)		
Intermediate risk, No. (%)	831 (84.0)	830 (84.1)		
High risk, No. (%)	158 (16.0)	157 (15.9)		
Surgical approach, No./total (%)				
Abdominal Laparoscopic	732 / 894 (81.9)	721 / 884 (81.6)		
Abdominal open	162 / 894 (18.1)	163 / 884 (18.4)		
Intraabdominal pressure during laparoscopy, mmHg	14.7 (3.6)	14.5 (2.5)		







Further characteristics of surgery

	High PEEP n=989	Low PEEP n=987	P value
Priority of surgery, No.(%)			
Elective	962 (97.8)	958 (97.6)	
Emergency	13 (1.3)	11 (1.1)	0.64
Urgent	9 (0.9)	13 (1.3)	
Positioning during surgery, No.(%	6)		
Supine	357 (36.2)	367 (37.2)	
Trendelenburg	86 (8.7)	69 (7.0)	
Reverse Trendelenburg	486 (49.3)	491 (49.8)	0.69
Lithotomy	17 (1.7)	16 (1.6)	
Seated	39 (4.0)	43 (4.4)	
Surgical wound classification, No).(%)		
Clean	514 (52.1)	525 (53.2)	
Clean-contaminated	461 (46.8)	450 (45.6)	0.46
Contaminated	10 (1.0)	7 (0.7)	
Dirty	1 (0.1)	4 (0.4)	
ESA	PROBESE		PR@tective VENTILATION

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NETWORK

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Ventilation and intraoperative characteristics

Characteristic	High PEEP (n = 989)	Low PEEP (n = 987)	Absolute difference (95% CI)	P value
Tidal volume – mL/kg After induction First hour Last hour	7.2 (1.4) 7.2 (1.5) 7.3 (1.6)	7.1 (0.7) 7.1 (0.4) 7.1 (0.6)	0.0 (-0.0 to 0.2) 0.1 (0.0 to 0.2) 0.1 (0.0 to 0.2)	0.15 0.007 0.008
PEEP – cmH ₂ O After induction First hour Last hour	11.5 (2.0) 12.0 (1.1) 12.1 (1.1)	4.0 (0.7) 4.0 (0.5) 4.1 (0.7)	7.5 (7.4 to 7.6) 7.9 (7.9 to 8.0) 8.0 (7.9 to 8.1)	< 0.001 < 0.001 < 0.001
Patients receiving recruitment maneuvers, No. (%) After induction First hour Last hour Number, median (IQR)	972(98.3) 968 (97.9) 951 (96.2) 968 (97.9) 4 (3 - 5)	11 (1.1) 	97.1 (96.1 to 98.2) 	< 0.001
Duration of surgery – hours, median (IQR)	2.5 (2.0 – 3.3)	2.5 (2.0 – 3.3)	0.0 (-0.1 to 0.1)	0.62
Duration of anesthesia – hours, median (IQR)	3.2 (2.5 – 4.2)	3.2 (2.5 – 4.2)	0.0 (-0.1 to 0.2)	0.94







Peak pressure



Driving pressure











Postoperative Pulmonary Complications at day 5 after Surgery



Postoperative Pulmonary Complications at day 5 after Surgery



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Severe Postoperative Pulmonary Complications at day 5 after Surgery









Primary outcome

Postoperative Pulmonary Complications

Risk Ratio (99.58% CI)









Extrapulmonary Postoperative Complications at day 5 after Surgery





Secondary outcomes

	High PEEP (n = 989)	Low PEEP (n = 987)	Absolute difference	Effect Estimate (95% CI)	P value
* post-hoc analysis					
Severe PPC	11		DEED	D – 1.05)	0.22
Extrap complication	16	LOW	FEEF	5 – 1.19)	0.31
Impaired wound healing	² Desa	aturation		+4 % ³ - 1.24)	0.55
ICU admission	4	High PE	EP & RI	V – 1.38)	0.29
HFD 90	ва Нуро	otension		+9% ^{2.16 –}	0.27
Hypoxemia	4 Vaso	bactive di	rugs	+3%) - 0.65)	< 0.001
Hypotension	31	Hoopital	mortali	4 – 1.56)	< 0.001
Bradycardia	9	nospital	mortan	– 1.45)	0.001
In-hospital mortality	1 High	PEEP	Low	PEEP 5 - 1.81)	0.09
Rescue desaturation*	⁵ 12/9	89 (1.2)	5/597	7(0.5) ^{9-0.62)}	< 0.001
Vasoactive drugs*	49	P <	(0.09)	– 1.21)	0.02
5-days*	t in the second s) — 6.97) ^j	0.48







Inspiratory Oxygen Fraction









Oxygen Saturation during surgery









Postoperative dyspnea and pain

	High PEEP n=989	Low PEEP n=987		
VAS dyspnea – cm, n	nean (SD), No.			
Day 1	1.8 (1.5), 912	1.8 (1.4), 917	0.53	
Day 2	1.4 (1.0), 840	1.5 (1.0), 844	0.57	
Day 3	1.4 (0.9), 619	1.3 (0.8), 617	0.68	
Day 4	1.3 (0.9), 461	1.3 (0.8), 459	0.79	
Day 5	1.2 (0.9), 336	1.2 (0.8), 330	0.78	
VAS abdominal rest	pain – cm, mean (SD), No	Э.		
Day 1	2.7 (1.8), 950	2.9 (1.9), 958	0.10	
Day 2	2.1 (1.5), 881	2.1 (1.4), 889	0.31	
Day 3	1.8 (1.3), 647	1.8 (1.2), 650	0.94	
Day 4	1.6 (1.2), 469	1.6 (1.0), 475	0.75	
Day 5	1.5 (1.0), 346	1.5 (1.0), 337	0.83	







Risk ratios for PPC in subgroups

	High PEEP		Low PEEP		Favors High PEEP	Favors Low PEEP		P Value for
Subgroups	PPC	Total	PPC	Total			Risk Ratio (95% CI)	Interaction
Type of Surgery								0.075
Non-laparoscopic	79	240	74	253		 i	1.09 (0.90 - 1.32)	
Laparoscopic	130	740	156	727	⊢-∎1		0.88 (0.77 - 1.01)	
BMI								0.967
< 40 kg/m2	76	336	94	376	⊢-∎-		0.93 (0.77 - 1.13)	
≥ 40 kg/m2	135	653	139	611		-	0.94 (0.82 - 1.08)	
Baseline SpO2								0.351
< 96%	88	317	112	342		ł	0.88 (0.74 - 1.06)	
≥96%	123	672	121	645	⊢-∎		0.99 (0.86 - 1.13)	
Type of Incision								0.111
Peripheral	32	126	25	126	F		1.16 (0.89 - 1.53)	
Upper abdominal	179	863	208	861	⊢∎ -1		0.90 (0.80 - 1.02)	
Waist-Hip Ratio								0.651
< 1.0 cm	97	467	100	457			0.97 (0.83 - 1.13)	
≥ 1.0 cm	98	447	112	449	⊢∎	H	0.92 (0.78 - 1.08)	
All Patients	211	989	233	987			0.93 (0.83 - 1.04)	

ESA Clinical Trial Network



Risk Ratio (95% CI)



Discussion

- Largest trial on mechanical ventilation
- Pragmatic approach
- High adherence to the protocol
- Highest difference in driving pressure
- Concurrent effects on lung function vs haemodynamics
- Non-individualized PEEP (but within the range to keep the lung open at exp, EIT)
- Postoperative measures not standardized (but strongly recommended)

Conclusions

- Among surgical obese patients, intraoperative high PEEP with recruitment manoeuvres PEEP did not reduce PPCs compared with low PEEP
- Low PEEP was associated with overall less risk of adverse events as compared to high PEEP
- Obese patients should be ventilated with with low tidal volume (7 ml/Kg PBW), PEEP equal or below 5 cmH₂O and no recruitment maneuvre
- \succ In case of desaturation, increase FiO₂ up to 90%
- Clinicians might choose PEEP to improve lung function or maintain haemodynamic, as indicated

Higher PEEP & Recruitment during Anesthesia: Don't listen the sounds of Sirens !

Pelosi P et al. Anaesth Crit Care Pain Med. 2019 Apr;38(2):91-93. Ball L et al. Crit Care. 2019 May 16;23(1):176.



Thanks to the PROVEnet investigators & the PROBESE collaborative group - is an outlier !



Pelosi P for the PROVE Network (www.provenet.eu)

Thanks to the PROBESE Italian Team







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Thanks to The European Society of Anaesthesiology







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Pelosi P for the PROVE Network (<u>www.provenet.eu</u>)

Protective Mechanical Ventilation During General Anesthesia (in Obese and non Obese Patients)



Low Tidal Volume (7 ml/Kg PBW), Low PEEP (5 cmH2O or less), no RM If oxygen desaturation – Increase FiO2 up to 90%

Pelosi P for the PROVE Network (www.provenet.eu)

What also 2

Low PEEP vs High PEEP & Recruitment

By using Low PEEP (PROVEnet 2014-2019):

- I on 5 patients without hypotension
- I on 10 patients without vasoactive drugs
- I on 10 patients need increased FiO₂ (< 10%)</p>
 - By using Low PEEP (in non obese patients): 320 million operations in Europe (Lancet 2015)
- 64 million patients without hypotension
- ✤ 32 million patients without vasoactive drugs
- ✤ 32 million patients need increased FiO₂ (< 10%)</p>

By using Low PEEP (in obese patients):

- 400.000 operations in Europe (IFSO 2018)
- 80.000 patients without hypotension
- 40.000 patients without vasoactive drugs
- 40.000 patients need increased FiO₂ (< 10%)</p>

TRULY A SAD DAY Euroanaesthesia 5 June 2019 Vienna - Austria

For Moderate to High PEEP Lovers !

Pelosi P for the PROVE Network (www.provenet.eu)

The Funeral for Positive End-Expiratory Pressure ... better known as PEEP

"It was a dream for generations of Anesthesiologists and Intensivists"



Thou seest I have more flesh than another man, and therefore more frailty

addine Pl

STORE THE

Thanks !

Pelosi P for the PROVE Network (www.provenet.eu
Regional transpulmonary pressures during mechanical ventilation in obesity

Schetz M et al. Intensive Care Med 2019 Jun;45(6):757-769



Pelosi P for the PROVE Network (www.provenet.eu)





High versus low positive end-expiratory pressure during general anaesthesia for open abdominal surgery (PROVHILO trial): a multicentre randomised controlled trial

The PROVE Network Investigators* for the Clinical Trial Network of the European Society of Anaesthesiology

PROVHILO





Varese 2009

- Open abdominal surgery
- ARISCAT > 26
- Low $V_T = 7 \text{ ml/Kg PBW}$
- $Low PEEP = 2 cmH_2O$
- High PEEP = $12 \text{ cmH}_2\text{O} + \text{RM}$
- PPCs at 5 days

Postoperative Pulmonary Complications at day 5 after Surgery (non obese)

The PROVEnet investigators. The Lancet 2014 Aug 9;384(9942):495-503



Pelosi P for the PROVE Network (www.provenet.eu)

How I (We) ventilate obese patients (iSTART) Pelosi P, Ball L Crit Care. 2019 May 16;23(1):176

Intubate

- · Anticipate difficult airway management and difficult mask ventilation
- Preoxygenate with FiO₂ 100% and non-invasive positive pressure ventilation
- Fluids and vasoactive drugs readily available for possible haemodynamic impairment

Set - Up Initial Ventilation

- Tidal volume: 4-6 ml/kg PBW in ARDS, 6-8 ml/kg in non-ARDS, volume controlled/guarantee modes
- Low-moderate PEEP (ARDSnet low-PEEP table in ARDS, start with 5 cmH₂O in non-ARDS)
- Gradually lower FiO₂ (to target normoxya in ARDS and non-ARDS)

Titrate Ventilation Parameters

- Respiratory rate: to keep pHa > 7.25 in non-ARDS and ARDS, tolerate mild hypercapnia in ARDS
- PEEP: minimal to keep PaO₂ 55-80 mmHg or SatO₂ 88-92% in ARDS and non ARDS, no routine recruitment
- · FiO2: avoid hyperoxia, if desaturation prioritise FiO2 increase over PEEP increase

Assess Harmfulness of Ventilation

- Plateau pressure: target below 27 cmH₂O + (IAP 13)/2 in ARDS, 20 cmH₂O + (IAP 13)/2 in non-ARDS
- Driving pressure (plateau-PEEP): target below 17 cmH₂O in ARDS and 15 cmH₂O in non-ARDS
- Mechanical power: target below 17-20 J/m

Rescue Strategies

- Recruitment Maneuvers: only as rescue, stepwise increase in airway pressure
- Prone positioning: also safe and feasible in obese ARDS
- ECMO: consider in selected ARDS patients



Atelectasis during General Anesthesia

Nyman G et al. Equine Vet J 1990, 22:317-324







Recruitment maneuvre & PEEP in obese patients

Reinius H et al. Anesthesiology 2009; 111:979-987



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