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Mechanical Ventilation Practices in the Operating Room. Survey of the Anesthesiology Society of Charleroi "VENTISAC"

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Abstract : Background: Lung protective mechanical ventilation, which refers to the use of low tidal volumes, of positive end-expiratory pressure (PEEP) and of recruitment maneuvers (periodic hyperinflation of the lungs), has been shown to reduce mortality among patients with acute respiratory distress syndrome and is now considered the best practice in the care of many critically ill patients.

For several years, many studies have suggested that, among patients without lung injury, lung-protective mechanical ventilation in a surgical procedure may also lead to better clinical outcomes.

Indeed, clinical and experimental studies have shown that mechanical ventilation, especially using high tidal volumes, could induce lung injury by alveolar overdistension, phenomena of repeated alveolar collapse and expansion and release of inflammatory mediators contributing to pulmonary and extrapulmonary organ dysfunction. Pulmonary and immune cells can convert mechanical stimuli into biological signals that will lead to inflammation. This sterile inflammation, both locally and systemically, will cause immunosuppression.

So, lung protective mechanical ventilation can reduce ventilator-associated lung injury and postoperative pulmonary complications, for both patients with or without healthy lungs.

The purpose of this study 'VENTISAC' is to examine how the members of the SAC (Anesthesioloy Society of Charleroi) adhere to this concept in general anesthesia in the operating room.

Method : a computing questionnaire of 30 questions sent by electronic mail to the 250 members, all of them being either recognized anesthesiologists or assistant anesthesiologists completing their training. The results will be compared with those of the study "VENTILOP" of 2011 carried out in Alsace.

Results : 38 % of the members of the SAC have responded completely.

24.2 % of the participants set the peroperative ventilation parameters minimally, that means using low tidal volume (6-8mL/ideal body weight), often positive end expiratory pressure and sometimes FiO_2 below 50%.

Only 6.3 % of the professionals set the peroperative ventilation parameters optimally, associating low tidal volume (6-8mL/ideal body weight), systematic positive end expiratory pressure, frequently FiO_2 below 50%, systematic I/E ratio adjustment and recruitment maneuvers.

Conclusion : Our study, as the Alsatian survey, confirms an insufficient clinical practice of the so-called lung "protective" mechanical ventilation, not by disinterest but by lack of knowledge of the concept. Training meetings concerning protective mechanical ventilation are a request expressed by all the participants in this survey.

Introduction

The so-called lung "protective" mechanical ventilation has been used for many years for the management of patients with acute respiratory distress syndrome (ARDS) in our intensive care units (1). This practice consists in an optimal setting of the following ventilatory parameters: low tidal volume based on predicted body weight (PBW) rather than actual body weight, positive-end expiratory pressure (PEEP), recruitment maneuvers, fraction of inspired oxygen (FiO_2) and inspiratory to expiratory time ratio (I/E ratio).

Indeed, it has proven benefit in the reduction of morbidity and mortality in these patients (2) (3).

Almost all patients under general anesthesia for surgery need mechanical ventilation. Prior to the 2000s, the use of high tidal volumes (10 to 15 mL per kilogram of predicted body weight) was traditionally recommended to prevent hypoxemia and atelectasis in anesthetized patients.

Experimental and observational studies of the last several years among patients with healthy lungs have demonstrated that mechanical ventilation with high tidal volumes can initiate ventilator-associated lung injury through an augmentation in phenomena of alveolar overdistension as well as phenomena of repeated alveolar collapse and expansion. This same mechanical ventilation can also contribute to

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extrapulmonary organ dysfunction through systemic release of inflammatory mediators, resulting in prolonged mechanical ventilation, hemodynamic in-stability, multiple organ failure, and prolonged ICU stay (4) (5).

As expected, the interest of this so-called lung "protective" ventilation in the operating room was subsequently extended to ventilated patients with healthy lungs, several studies indicating a reduction in postoperative respiratory complications (6).

The main purpose of this study is to examine the adherence to this concept of so-called "protective" ventilation in general anesthesia by the Belgian anesthe-siologists who live in the regions of Wallonia and Brussels and who are members of the Anesthesiology Society of Charleroi (SAC).

The secondary purpose of this survey is to compare its results with the ones of the study carried out in Alsace by our French colleagues (F. Fischer and O. Collange in 2011 (VENTILOP survey) (7) and to evaluate a possible request for training in the field of protective ventilation.

Method

From January 2015 to March 2015, an electronic questionnaire comprising 30 questions was sent by electronic mail to the 250 members of the Anesthesiology Society of Charleroi (SAC), all of them being either recognized anesthesiologists or anesthesiologists in training. These work mostly in Belgium, in the province of Namur and Hainaut. More precise data on the targeted population have not been requested and are therefore not available.

The agreement of the Ethics committee wasn't needed as this questionnaire was sent to health profes-sionals about their professional practice, without any sensitive character.

The questionnaire was the same as the one of the "VENTILOP survey" and included :

– the professional status of the interviewed person
– the setting of the following ventilatory parameters :
- Tidal volume (Vt) (<6 mL/kg; 6 mL/kg; 8 mL/kg ; 10 mL/kg ; 12 mL/kg ; <12 mL/kg)
- Predicted body weight (PBW)
- Inspiratory to expiratory time ratio (I/E ratio) (*never, rarely, frequently, for each patient)*
- Positive-end expiratory pressure (PEEP) (*never, rarely, sometimes, frequently, systematically*)
- Recruitment maneuvers (*never, occasionally, regularly*) and description of the one which is used
- Fraction of inspired oxygen < 50% (frequently, sometimes, rarely, never)

– the potential interest of meetings focused on training in the field of the "protective" ventilation.
– the necessity of developing formal recommendations on the optimization of mechanical ventilation.

As proposed by our French colleagues in their VENTILOP survey (7) carried out in 24 hospital establishments in Alsace, the ventilator settings were considered:

– as minimal when the four following parameters were present :
- Vt setting between 6 and 8 mL/kg
- Vt calculated using PBW
- frequent use of PEEP
- sometimes setting of FiO_2 below 50%

– as optimized when the six following parameters were present :
- Vt setting between 6 and 8 mL/kg
- Vt calculated using PBW
- systematic use of PEEP
- frequent setting of FiO_2 below 50%
- systematic setting of I/E ratio
- setting of recruitment maneuvers

(The meaning of "frequent" was left to the judgment of the person answering the questionnaire.)

Statistical method

The questionnaire was developed using the one-line computer tool "Formsite" (www.formsite.com).

This system automatically entered the data as an Excel file.

Some data were analyzed using Chi square test or Fisher's exact test as appropriate.

The differences were judged significant at p value of less than 0.05 ($p<0.05$).

The 95% Confidence Interval {95%IC} of a percentage were calculated to show how precise that value is.

Results

Participants :

38.0% of the members of the SAC (95 colleagues out of 250) responded by electronic mail to the questions of the declarative survey called "VENTISAC".

63.1% coming from public hospitals
36.8% coming from private hospitals

43.1%: anesthesiologists with more than 10 years' experience (= >10 years' exp.)
23.1%: anesthesiologists with less than 10 years' experience (= <10 years' exp.)
33.6%: anesthesiologists in training (= in training)

The great difference with the "VENTILOP" survey is the participation of Nurse Anesthetists (= Nurse Anest.).

	Nurse Anest.	In training	<10 years' exp.	>10 years' exp.	Partici-pants
VENTILOP	34,3% (59)	16,2% (28)	13,9% (24)	35,5% (61)	(172)
VENTISAC	0% (0)	33,6% (32)	23,1% (22)	43,1% (41)	(95)

Vt : Tidal volume calculated on the basis of the predicted body weight (PBW) :

95.3% say they use a tidal volume between 6 and 8 mL/kg but only 40.7% use the Predicted Body Weight (PBW) based on the size to calculate it. Inside that range of 6 to 8 mL/kg, ventilation is used by:

41.4% of the anesthesiologists who have more than 10 years' experience
40.9% of the anesthesiologists with less than 10 years' experience
43.7% of the anesthesiologists in training.
(p = 0.97)
Nobody has answered 12 mL/kg.

Inspiratory to expiratory time (I/E) ratio :

45.2% say they set it frequently
Only 13.6% say they set it for each patient

Setting I/E ratio	>10 years' exp.	<10 years' exp.	In training	p-value
Frequently	46.3% {31,0-61,5}	36.3% {16,2-56,4}	50.0% {32,7-67,3}	0.60
For each patient	17.0% {5,5-28,5}	13.6% {-0,7-27,9}	6.2% {-2,1-14,5}	0.54

In case of setting, 33.0% say they set the I/E ratio in case of obstructive respiratory disease, 27.0% to limit insufflation pressures, 19.0% according to the expiratory flow curve and 7% according to the inspiratory flow curve.

Positive-end expiratory pressure (PEEP) :

No member of the SAC says she or he never uses it.

46.3% say they use it often.
36.8% say they use it in a systematic way.
16.8% say they only use it sometimes or rarely

PEEP	>10 years' exp.	<10 years' exp.	In training	p-value
Often	53.6% {38,3-68,9}	54.5% {33,7-75,3}	31.2% {15,1-47,2}	0.17
Systematic	29.2% {15,3-43,1}	31.8% {12,3-51,3}	50.0% {32,7-67,3}	0.26
Sometimes, rarely	17.0% {5,5-28,5}	13.6% {0,7-27,9}	18.7% {5,2-32,2}	0.88

Recruitment maneuvers :

84.2% say they use it
38% to fight hypoxemia
36% to limit atelectasis

Recruitm. maneuv.	>10 years' exp.	<10 years' exp.	In training	p-value
	82.9% {71,4-94,4}	90.9% {78,9-99,9}	81.2% {67,7-94,7}	0.62

As regards the procedures for achieving recruiting maneuvers during the operating time, most of the 74 people (out of 95) who answered the question described different procedures.

FiO_2 below 50% :

57.8% say they frequently set the FiO_2 below 50% if it is possible, in absence of hypoxemia.

FIO_2 below 50%	>10 years' exp.	<10 years' exp.	In training	p-value
Frequently	63.4% {48,6-78,1}	45.4% {24,6-66,2}	59.3% {42,3-76,3}	0.48

16.8% say they sometimes set it below 50%.

Answering the question "Do you know protective ventilation ?"

41.2% of the members of the SAC say they only know it moderately or badly,
58.7% say they know it well and very well.

Answering the question "Do you have the necessary knowledge to optimize ventilation ?"

14.5% admit there is a lack in their knowledge.
55.2% say they need more training in that field, with among them : 63.4% (95%IC {48,6-78,1}) of the anesthesiologists with more than 10 years' experience, 50.0% (95%IC {29,1-70,9})

of the anesthesiologists with less than 10 years' experience, 50.0% (95%IC {32,7-67,3}) of the anesthesiologists in training (p = 0.69).

84% think it is necessary to develop formal recommendations on peroperative ventilation and its optimization strategies in anesthesiology.

92.6% think that meetings of training would improve their practice in the field.

100.0% are ready to participate in a meeting of training.

24.2% (95%IC {15,6-32,8}) of the participants set the peroperative ventilation parameters **minimally**, that means using low tidal volume (6-8mL/ideal body weight), often positive end expiratory pressure and sometimes FiO_2 below 50%.

Only **6.3%** (95%IC {1,4-11,2}) of the professionals set the peroperative ventilation parameters **optimally**, associating low tidal volume (6-8mL/ideal body weight), systematic positive end expiratory pressure, frequently FiO_2 below 50%, systematic I/E ratio adjustment and recruitment maneuvers.

Discussion

Our "VENTISAC" survey is a declarative survey carried out by electronic mail in which more than one third of the members of the Anesthesiology Society of Charleroi took part. At the end of the survey, all of them said that they would be willing to take part in a future meeting of training which would enable them to improve their practice in the field of peroperative mechanical ventilation, which shows a real interest in the subject.

Of course, this survey, due to its declarative nature, contains many biases, but compared with the "VENTILOP" survey by our colleagues in Alsace (7), our study confirms an insufficient knowledge and practice of the so-called lung "protective" ventilation, not by disinterest but by lack of knowledge of the concept.

The setting of the Tidal Volume (Vt) on 6 to 8 mL/kg, which is well admitted by most of the interviewed anesthesiologists-resuscitators (95.3%), is still poorly applied, with only 40.7% using the Predicted body weight (PBW) of the patient to calculate it, which supposes that 59.3% of the practitioners still apply Tidal Volumes which are too high, with risks of alveolar overdistension, of phenomena of repeated alveolar collapse and expansion favoured by the the absence of peep.

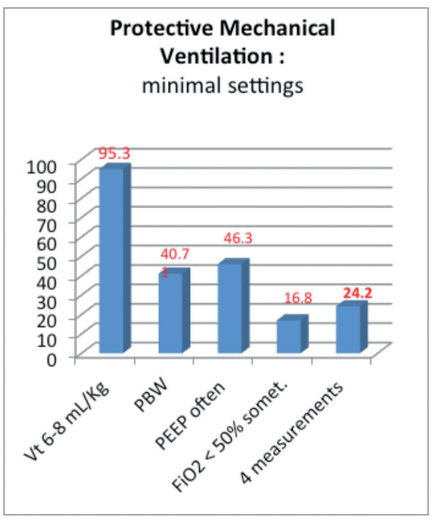
The study of Zupancich *et al.* has also demonstrated that pulmonary and systemic pro-inflammatory cytokine levels increase in patients ventilated with high tidal volumes but not in those ventilated with low tidal volumes (4) (8). The use of high tidal volume is today recognized as an independent risk factor for prolonged mechanical ventilation, hemodynamic instability, multiple organ failure and prolonged ICU stay. Obese patients are more at risk of receiving injurious ventilation by a tidal volume calculated on actual body weight.

Indeed, pulmonary and immune cells can convert mechanical stimuli into biological signals that will lead to inflammation (9).

This sterile inflammation, both locally and systemically, will cause immunosuppression. So, "protective" mechanical ventilation can reduce ventilator-associated lung injury and postoperative pulmonary complications.

2 anesthesiologists in training of 32 surprisingly say that they still ventilate outside the range 6 to 8 mL/kg.

57.8% of the interviewed physicians say they often set the FiO_2 below 50%. It is important to pay attention to it as the excess of O_2 induces atelectasis through nitrogen resorption. Some studies have also shown that a high FiO_2 could reduce the post-surgical infection rate, notably through an increase of the tissue partial pressure in O_2 provided the hemodynamic status and the tissue microcirculation are maintained, which can perhaps explain the practices of the other half of the interviewed physicians (10) (11).



Nobody participating in the survey answers she or he "never uses the PEEP" (compared with 10.5% in the "VENTILOP" survey; p < 0.05), which is a good thing, and a little more than one third of the interviewed people (36.8%; 95%IC {27,1-46,5}) say they use it systematically (compared with 30.0% ; 95IC {23,1-36,8}) in the "VENTILOP"

survey ; p = 0.22). The systematic use of the PEEP seems more frequent in the group of the assistants in training (50%; 95%IC {32,7-67,3}) than in the group of the experienced anesthesiologists (<10 years' exp.: 29.2%; 95%IC {10,2-48,2} ; >10 years' exp. : 31.8%; 95%IC {17,5-46,0) but is not statistically significant (p = 0.26). It allows to hope that its use will become more frequent in the operating rooms in the future and that it will hence be made necessary in case of mechanical ventilation, whether protective or not. The results of the studies of Treschan *et al*. in 2012 (12) and Futier *et al*. in 2013 (13) could indeed have suggested that the beneficial effects of protective ventilation were perhaps only linked with the use of a PEEP, whatever the Tidal volume used, 10-12 mL/kg or 6-8 mL/kg.

Only the PEEP seems to avoid the risk of cyclic opening and closing of alveoli, which is responsible for a decrease of compliance, but the interest of achieving recruitment maneuvers in peroperative ventilation appears to be more and more demonstrated (14).

In 2015, 84.2% (95%IC {76,9 - 91,5}) of the members of the SAC say that they use recruitment maneuvers, compared with 30.0% (95%IC {23,1 - 36,8}) in 2011 in the "VENTILOP" survey (p < 0.05). As regards the procedures of achievement of recruitment maneuvers during the operating time, they were described as very different from each other, which quite agrees with the existing literature, as to our knowledge, there is no consensus on the best way to achieve them.

This significant difference can presumably be explained by the fact that most of the surveys recommending recruitment maneuvers were carried out after 2011.

"A systematic review of the literature" (15), published in 2014, show that the practice of recruitment maneuvers allows a significant improvement in PaO_2, FRC and compliance.

Indeed, the PEEP alone cannot open the alveoli, but the recruitment maneuvers are the ones that can keep the alveoli open through opposing the retraction forces.

Some think that recruitment maneuvers and the implementation of a PEEP are inseparable.

The so-called lung "protective" ventilation strategy should probably be applied to all patients.

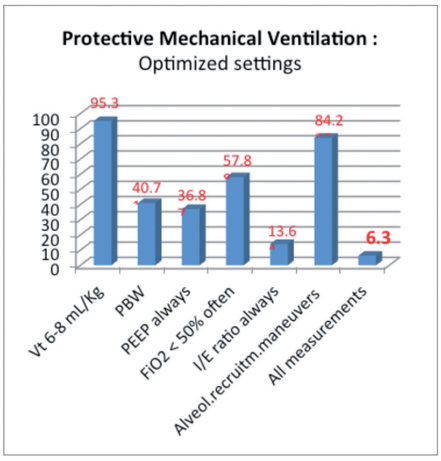
The patients undergoing minor surgery, peripheral or non-invasive, will certainly get only few benefits from it, but why couldn't they benefit ?

The so-called lung "protective" ventilation will mainly be beneficial to the patients undergoing major and/or long surgery, mainly if it is abdominal, thoracic or cardiac, and also the patients at increased risk of pulmonary complications**:** patients who are obese, aged, smoking, etc… However, it is regrettable that in the surveys on protective ventilation, the cardiac patients, or the patients with COPD, asthma were often excluded from the studied populations. Other surveys including that type of patients should still be carried out.

All in all, only **6.3%** (95%IC {1,4 - 11,2}) of the professionals in the "VENTISAC" survey have said they set the peroperative ventilation parameters optimally, that means with a Tidal Volume of 6 to 8 mL/kg Predicted body weight (PBW), a systematic use of a PEEP, a systematic setting of the I/E ratio, a FiO_2 below 50% if possible and recruitment maneuvers, compared with **2.3%** (95%IC {0,0-4,5}) of the professionals in the "VENTILOP" survey. But this difference is not statistically significant (p = 0.10). However, the exclusive participation of Nurse Anesthetists in the "VENTILOP" survey could be taken into account.

More than half of professionals, as their colleagues in Alsace did 5 years before, recognize that they need more training.

Finally, a lot of the interviewed people wish for formal recommendations on peroperative ventilation and optimization strategies in anesthesiology.

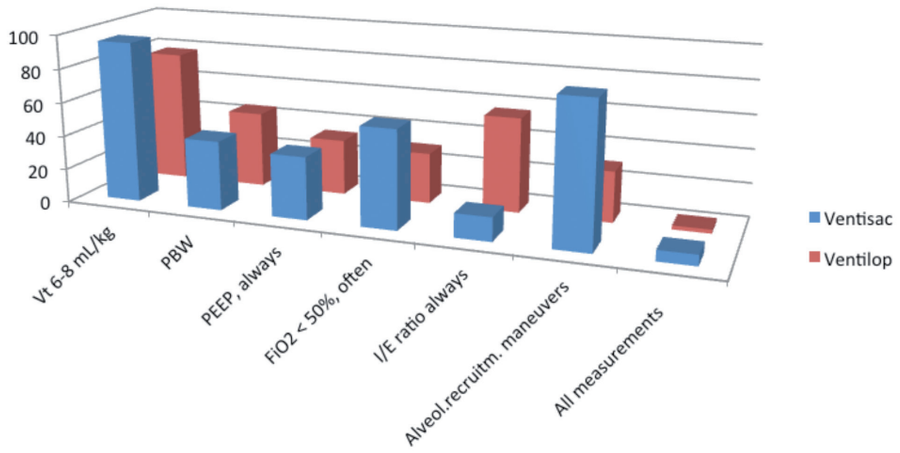


Conclusion

If we compare with the "VENTILOP" survey of 2011 carried out in Alsace, our "VENTISAC" survey shows quite similar results, with a use of protective ventilation in anesthesiology which is still too low today because of a lack of knowledge. Today, recruitment maneuvers are more often used but formal recommendations are still necessary.

As all the anesthesiologists (including anesthe-

Comparison of surveys VENTISAC (2015) and VENTILOP (2011) (p = 0.10)



siologists in training) who have answered the questionnaire have unanimously expressed the wish to take part in training meetings, as a society, we should feel encouraged to persevere and organize those meetings.

So, the need for training remains an important reality among the anesthesiologists, and this a great opportunity for improvement.

Bibliography

1. The Acute Respiratory Distress Syndrome Network. Brower RG., Matthay MA., Morris A., Schoenfeld D., Thompson BT., Wheeler A., *Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome*. N. Engl. J. Med., **5342**, 1301-8, 2000.
2. Amato MB., Barbas CS., Medeiros DM. *et al*., *Effect of a protective-ventilation strategy on mortality in the acute respiratory distress syndrome*. N. Engl. J. Med., **338**, 347-54, 1998.
3. J. Villar, RM. Kacmarek, L. Pérez-Mendez, A. Aguirre-Jaime. *A high positive end-expiratory pressure, low tidal volume ventilatory strategy improves outcome in persistent acute respiratory distress syndrome: a randomized, controlled trial*. Crit. Care Med., **34**(5), 1311-1318, 2006.
4. Zupancich E, Paparella D, Turani F, Munch C, Rossi A, Massaccesi S, Ranieri VM., *Mechanical ventilation affects inflammatory mediators in patients undergoing cardiopulmonary bypass for cardiac surgery : A randomized clinical trial*. J. Thorac Cardiovasc Surg, **130**, 378-83, 2005.
5. Lellouche F, Dionne S, Simard S, Bussieres J, Dagenais F. *High tidal volumes in mechanically ventilated patients increase organ dysfunction after cardiac surgery*. Anesthesiology, **116**, 1072-1082, 2012.
6. Futier E, Jaber S., *Lung protective ventilation in abdominal surgery*, Current Opin Crit Care, **20**(4), 426-30, 2014.
7. Fischer F, Collange O, Mahoudeau G. *et al*., *Enquête VENTILOP*, Ann Fr Anesth Reanim., **33**, 389-394, 2014.
8. Determann RM, Royakkers A, Wolthuis EK. *et al*. *Ventilation with lower tidal volumes as compared with conventional tidal volumes for patients without acute lung injury : A preventive randomized controlled trial*. Crit Care, **14**, R1, 2010..
9. J.M. Tadié, A. Gacouin, Y. Le Tulzo., *Dysfonction immunitaire induite par la ventilation mécanique Ventilator-induced immune dysfunction*. Réanimation, **23**, 9-16, 2014.
10 Hopf HW, Holm J. *Hyperoxia and infection*. Best. Pract. Res. Clin. Anesthesiol., **22**, 553-69, 2008.
11. Belda FJ, Aguilera L, Garcia A. *et al*., *Supplemental perioperative oxygen and the risk of surgical wound infection : a randomized controlled trial*. JAMA, **294**, 2035-42, 2005.
12. Treschan TA, Kaisers W, Schaefer MS, Bastin B, Schmalz U, Wania V. *et al*., *Ventilation with low tidal volumes during upper abdominal surgery does not improve postoperative lung function*, Br. J. Anaesth., **109**, 263-271, 2012.
13. Futier E, Constantin JM, Paugam-Burtz C. *et al*., *Improve Study Group : A trial of intraoperative low-tidal-volume ventilation in abdominal surgery*. N. Engl. J. Med, **389**, 428-37, 2013.
14. Severgnini P, Selmo G, Lanza C., *et al*., *Protective mechanical ventilation during general anesthesia for open abdominal surgery improves postoperative pulmonary function*. Anesthesiology, **118**, 6, 1307-1321, 2013.
15. Benjamin L Hartland, Timothy J Newell, RN and Nicole Damico. *Alveolar Recruitment Maneuvers Under General Anesthesia : A Systematic Review of the Literature*. Resp Care (2014).