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Alexandra Odo

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**VENTILATION INVASIVE INITIÉE EN MÉDECINE D'URGENCE :
ÉTUDE PROSPECTIVE MONOCENTRIQUE AU CHU DE
GRENOBLE-ALPES : RÉSULTATS FINAUX DE L'ÉTUDE AREVISS :
ANALYSE DES RÉGLAGES VENTILATOIRES INITIÉS PAR
L'ÉQUIPE DU SAMU OU DU SAU**

THÈSE

POUR LE DIPLÔME D'ÉTAT DE DOCTEUR EN MÉDECINE

SPÉCIALITÉ : MÉDECINE D'URGENCE

Par Mme Alexandra ODO

[Données à caractère personnel]

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MCF Ass.MG	Maître de conférences des universités de médecine générale associé (à mi-temps)
PAST	Professeur associé en service temporaire

TABLE DES MATIERES

REMERCIEMENTS	7
ABRÉVIATIONS	11
RESUMÉ.....	12
ABSTRACT	13
I. INTRODUCTION.....	14
II. MATERIAL AND METHOD.....	15
1. Study setting and participants.....	15
2. Data collection and analysis	15
3. Endpoints.....	16
a) Primary endpoint	16
b) Secondary endpoints.....	16
4. VENTILO application.....	16
5. Number of subjects required.....	17
6. Statistics	17
III. RESULTS.....	18
IV. DISCUSSION	26
Limitations	29
V. CONCLUSION	30
BIBLIOGRAPHIE	32
APPENDICES.....	37
SERMENT D'HIPPOCRATE	42

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ABRÉVIATIONS

- ARDS : Acute Respiratory distress Syndrome / SDRA : Syndrome de Détresse Respiratoire Aigüe
- BMI : Body Mass Index / IMC : Indice de Masse Corporelle
- BVM : Bag Valve Mask / BAVU : Ballon Autoremplisseur à Valve Unidirectionnelle
- CHUGA : Centre Hospitalo-Universitaire Grenoble-Alpes
- ECMO : ExtraCorporeal Membrane Oxygenation
- ED : Emergency Departement / SAU : Service d'Accueil et de traitement des Urgences
- EtCO₂ : End Tidal Carbon dioxid, valeur du CO₂ en fin d'expiration
- FiO₂ : Fraction of Inspired Oxygen / Fraction Inspiratoire d'Oxygène
- ICU : Intensive Care Medicine / Soins intensif et Réanimation
- PEEP : Positive End Expiratory Pressure / PEP : Pression Expiratoire Positive
- PWB : Predicted Weight Body / PIT : Poids Idéal Théorique
- RR : Respiratory Rate / FR : Fréquence Respiratoire
- SAMU : Service d'Aide Médicale d'Urgente
- SpO₂ : Saturation of Peripheral Oxygen/ Saturation Pulsée en Oxygène
- VILI: Ventilator Induced Lung Injury, Lésions pulmonaires induites par le respirateur
- V_t : Tidal Volume / Volume Courant

RESUMÉ

Introduction : La ventilation mécanique invasive est une pratique courante en médecine d'urgence. Un volume courant (V_t) compris entre 6 et 8ml/kg de poids prédit pour la taille est recommandé dans la littérature afin de ne pas entraîner de lésions induites par la ventilation. L'utilisation d'un volume protecteur nécessite une augmentation de la fréquence respiratoire (FR) afin de maintenir une ventilation minute suffisante. L'objectif de cette étude est d'analyser les réglages des patients sous ventilation invasive au CHU de Grenoble-Alpes (CHUGA) et de déterminer le pourcentage de patients ventilés selon un V_t protecteur et une FR adaptée.

Méthode : Cette étude monocentrique prospective a été menée dans le Service des Urgences et le Service d'Aide Médicale Urgente (SAMU) du CHUGA de Mai 2021 à Mai 2022. Elle a recueilli les paramètres ventilatoires et les gaz du sang des patients âgés de plus de 18 ans, placés sous ventilation invasive, par un médecin travaillant aux urgences ou au SAMU du CHUGA. Le critère de jugement principal est déterminé en comparant le V_t et la FR réglés aux valeurs théoriques calculées avec l'aide de l'application VENTILO.

Résultats : Au total, 93 patients ont été inclus. Un V_t entre 6 et 8 ml/kg de PIT est utilisé pour 79,6 % de la population. La FR est adaptée à un V_t protecteur chez 21,5% des patients. Le V_t médian est à 6,45 ml/kg de PIT (6,06-7,12) et la FR médiane est à 16 (15-20). Il n'y a pas de facteur significativement associé à une ventilation protectrice.

Conclusion : Cette étude montre que l'utilisation du volume courant protecteur est intégré dans les pratiques, basée sur une attitude standard et non sur le poids idéal théorique. L'adaptation de la fréquence respiratoire au V_t est insuffisamment réalisée. Afin d'obtenir une ventilation personnalisée en fonction du poids idéal théorique et de la situation clinique, des applications dédiées existent et leur diffusion plus large pourrait permettre une meilleure prise en charge des patients à la phase initiale de la ventilation.

Mots clés : Ventilation mécanique / Ventilation protectrice / Urgence

Filière : Urgences / Préhospitalier

ABSTRACT

Introduction: Invasive mechanical ventilation is a common practice in emergency medicine. A tidal volume (Vt) of 6 to 8 ml/kg predicted body weight (PBW) is recommended in the literature to avoid ventilation-induced injury. The use of a protective volume requires an increase of the respiratory rate (RR) to maintain a sufficient minute ventilation. The objective of this study is to analyse the settings of patients undergoing invasive ventilation at the University Hospital of Grenoble-Alpes (CHUGA) and to determine the percentage of patients ventilated with a protective Vt and an adapted respiratory rate.

Method: This prospective monocentric study was conducted in the Emergency Department (ED) and in the prehospital medical system (called SAMU in France) at CHUGA from May 2021 to May 2022. It collected ventilatory parameters and blood gases of patients aged over 18 years, placed under invasive ventilation, by a doctor working in Grenoble ED or SAMU. The primary endpoint was determined by comparing the set VT and RR with the theoretical values calculated with the application « VENTILO ».

Results: A total of 93 patients were included. A Vt between 6 and 8 ml/kg PBW was used for 79.6% of the population. Respiratory rate was adapted to a protective Vt for 21.5% of patients. The median Vt was 6.45 ml/kg PWB (6.06-7.12) and the median RR was 16 (15-20). There were no factors significantly associated with protective ventilation.

Conclusion: This study shows that the use of protective tidal volume is integrated into practice, based on a standard attitude and not on the predicted body weight. The adaptation of respiratory rate to the Vt is not carried out sufficiently. In order to have a personalised ventilation according to predicted body weight and clinical situation, applications exist and their diffusion can lead to a better patient care at the initiation of ventilation.

Keywords: Mechanical ventilation/ Protective ventilation/ Emergency

Sector: Emergency department / Prehospital

I. INTRODUCTION

Invasive mechanical ventilation is initiated after an orotracheal intubation to support respiratory function and to protect the upper airway. In emergency medicine, it often occurs in different environmental conditions from an operating room (1) with a higher risk of failure and complications (2, 3). Despite these particularities, the few recommendations for mechanical ventilation in emergency medicine (4,5) are the same as in ICU, and physicians must apply them and adapt to the specific constraints of their practice.

Several studies have been conducted in the last century to understand and prevent ARDS. It enabled to identify the main settings for ventilation (6, 7) and tidal volume (V_t) is one of the most important. A high V_t can be responsible for the development of Ventilator-Induced-Lung-Injury (VILI) (8,9) at the onset of ventilation (10,11). Reducing V_t from 12 to 6 ml/kg of Predicted Body Weight (PBW) has been shown to reduce mortality in the management of ARDS (12).

The majority of patients admitted to the ICU have no pulmonary injury or ARDS, but are at risk of developing them, especially as the mechanisms of injury appear within hours (13,14) and the diagnosis of ARDS is underestimated and difficult (15,16). Early application of V_t between 6 and 8 ml/kg of PBW to this population (17), is associated with a decrease in lung injury and infection (18, 19), incidence of ARDS, duration of ventilation, ICU length of stay (20), and mortality in ICU (21). Protective ventilation with reduced V_t is increasingly used for all intensive care patients (22). It involves setting a higher respiratory rate (RR) than the physiological one to ensure sufficient minute ventilation and to avoid alveolar hypoventilation. A review of the literature demonstrated that the RR has been progressively increased and is currently set between 20 and 30 per minute, the minute ventilation of intensive care patients approaching 150 ml/kg_{PBW}/min (23). To obtain the optimal values of V_t and RR, applications can be used such as the application called “VENTILO”.

The LOV-ED study (24) is a study performed on a population of patients ventilated in the emergency department. It showed an absolute reduction of 7% in the risk of ARDS and suggested a reduction in mortality, length of stay in hospital and days under invasive ventilation after the application of a protocol using a V_t between 6 and 8 ml/kg of PBW and a RR of 20 to 30. Protective ventilation is feasible in the ED and has a preventive role, its initiation by emergency physicians also influences its adherence and continuation in the following management of patients (25).

Besides LOV-ED study, there are not many studies describing the setting of a RR adapted to a protected Vt in the ED and in pre-hospital. The objective of this study is to describe the practices of emergency physicians at the Grenoble University Hospital (CHUGA) after the initiation of an invasive ventilation. We wanted to determine the percentage of patients ventilated according to a protective ventilation, with a Vt between 6 and 8 ml/Kg of PBW and an adapted RR allowing a minute ventilation close to 150 ml/Kg. The theoretical values are calculated using the VENTILO application.

II. MATERIAL AND METHOD

1. Study setting and participants

This is an observational, monocentric and prospective study carried out in the emergency services of the Grenoble University Hospital (CHUGA) in France from 13/05/2021 to 12/05/2022. Emergency medicine in France is divided into two parts: the Emergency Department (ED) located in the hospital and the prehospital medical system called SAMU in French.

The population corresponds to patients aged over 18 years old, placed under invasive mechanical ventilation and intubated by an emergency physician working in the ED or in the SAMU of Grenoble and transferred to a service of the CHUGA.

Patients excluded are adults under legal protection (art. L1121-5 to L1121-8 of the French Public Health Code), patients who died before being admitted to the hospital, patients placed under invasive ventilation by a doctor working elsewhere than the ED or SAMU of Grenoble, and patients transferred to a service outside the CHUGA.

2. Data collection and analysis

Information was collected from a data collection sheet (see appendix) filled in by the emergency doctor who intubated and initiated mechanical ventilation. Then data were compared with those proposed by the VENTILO application. Data concerning the stay in the intensive care unit were collected on the patient's computer file.

3. Endpoints

a) Primary endpoint

The primary endpoint was the percentage of patients ventilated with a protective tidal volume (between 6 and 8 ml/kg of PBW) and an adapted respiratory rate allowing a minute ventilation close to 150 ml/Kg. The Vt and RR set by the emergency physician were considered protective if they were within the range determined by the VENTILO application.

b) Secondary endpoints

Ventilatory settings (mode of ventilation, Vt, RR, PEEP and FiO₂) and monitoring parameters (saturation, EtCO₂ and peak pressure) between the beginning and the end of the physician's care were compared to evaluate the adaptation of the ventilation parameters. pH, PaO₂ and PaCO₂ on the first blood gases were collected to assess the effect of mechanical ventilation initiated by the physician.

Temperature, different indications of intubation and experience of the physicians were analysed in order to observe a modification of the ventilatory parameters according to the pathology and the medical training.

Weight and height estimated by doctors compared to those measured in the services of the CHUGA, number of deaths, duration of ventilation and length of stay in the ICU were also collected.

4. VENTILO application

The VENTILO application is a free mobile application developed by Dr Lellouche and his team at the University Institute of Cardiology and Pneumology of Quebec, Laval University. It is presented as an aid to the initiation of ventilatory settings but should not replace the clinical judgment of the physician. Its development is supported by an important scientific literature, referenced and accessible in the application. The data requested by the application are gender, height in cm, weight (in order to calculate BMI), temperature and type of patient (scheduled or emergency surgery, intensive care patient).

According to the review of the literature made by Dr Lellouche and his team (21), a patient undergoing scheduled surgery would require a minute ventilation ($V_t \times RR / PBW$) about 100 ml/kg_{PBW}/min whereas an intensive care patient would require a minute volume about 150 ml/kg_{PBW} /min.

Some patients have an increased basal metabolic rate, such as patients with high BMI or fever. They require adaptation of the RR with a higher minute volume (26). The situation is reversed for hypothermic patients with a decreased basal metabolic rate (27).

All these parameters are taken into account in the application which will calculate a volume in ml and a RR adapted to the V_t according to the PBW. The V_t will be considered as protective within the range of 6 to 8 ml/kg of PBW. There is also a "ventilation optimisation" tab where we can find which parameters can be modified in ARDS to reduce dead space during protective ventilation. Illustrations of the application are available in the Appendices.

5. Number of subjects required

The Mechanical Ventilation and ARDS in ED study (28) from 2015, analysing ventilation parameters of 219 patients, found a protective ventilation rate of 55%. The LOVED study published in 2017 (24), including 1192 patients, shows 47% of patients ventilated protectively before the implementation of a protocol to assist ventilatory adjustments.

With the generalisation of protective ventilation to all intensive care patients, we suppose that this practice is increasingly performed in emergency medicine. We assume a protective ventilation rate of 60%. To obtain a confidence interval of the rate, deviating from 0.1, the number of subjects to be included is 93.

6. Statistics

Qualitative variables will be expressed as numbers and percentages (for descriptive analyses, rate of patients with protective ventilation, primary endpoint), compared by Pearson's chi 2 test or Fisher's exact test if appropriate. Numerical variables will be expressed as median and interquartile range (IQR), and compared using a Mann-Whitney test. The agreement of the measured and estimated morphological parameters (height, weight, BMI, PBW) will be assessed by a Bland and Altman representation with calculation of the mean

difference and the limits of agreement. A multivariate logistic regression analysis will be performed with the possible predictor variables of non-protective ventilation in univariate analysis (with $p \leq 0.1$) in order to determine the adjusted Odds Ratio of non-protective ventilation. Missing data will not be replaced. All tests will be two-tailed with an alpha risk of 0.05. Analyses will be performed using SPSS 22 software (IBM Corp., Armonk, NY, USA).

III. RESULTS

A hundred and one data collection sheets were collected during the study and 93 patients were included. There were 8 patients excluded, one patient was ventilated only with the BVM, one patient was intubated by an anaesthetist, two patients died before their arrival at the CHUGA, one patient was under legal protection and three patients were not included due to lack of information.

The characteristics of the population are described in Table 1. The majority of patients were male (64.4%) and 80.6% of patients were included in pre-hospital. The primary cause of intubation was neurological (68.8% of patients). This category includes head trauma, intracerebral haemorrhage, voluntary drug intoxication and acute alcohol poisoning. No patients had Covid 19.

There is a mortality rate of 41.9%, most deaths were related to intracerebral haemorrhage (19 patients) and cardiac arrest (13 patients).

Concerning the experience of doctors, it was divided into 4 categories: junior doctors (representing residents in last year in France), doctors with less than 5 years, between 5 and 10 years and more than 10 years of experience.

Table 1. Characteristics of the population (n=93)	
Place of inclusion, <i>n</i> (%):	
- Pre-hospital	75 (80,6)
- ED	18 (19,4)
Male, <i>n</i> (%)	60 (64,5)
Age (years)	56 (31-70) with min-max [18-88]
Estimated weight (kg)	75 (70-80) with min-max [50-120]
Estimated height (cm)	170 (165-176) with min-max [160-190]
BMI	24.8 (22.8-27.8) with min-max [17.3-46.9]
Temperature (°C)	36.3 (35.8-37) with min-max [25-38.5]
Covid, <i>n</i> (%)	0 (0)
Chronic respiratory disease, <i>n</i> (%)	7 (7,5)
Indication of intubation, <i>n</i> (%):	
- Neurological failure	64 (68,8)
- Cardiac arrest	25 (26,9)
- Respiratory failure	3 (3,2)
- Sedation for analgesic purposes	1 (1,1)
- Other	0 (0)
Hospitalisation service, <i>n</i> (%):	
- Medical ICU	34 (36,6)
- Neurosurgical ICU	21 (22,6)
- Cardiopulmonary and chest ICU	19 (20,4)
- Surgical ICU	14 (15,0)
- Other	5 (5,4)
Data in ICU:	
- Mortality at first month, <i>n</i> (%)	39 (41,9)
- ICU length of stay (days)	3 (1-6) with min-max [0-59].
- Days under ventilation	1 (1-3) with min-max [0-59].
Experience of emergency physicians, <i>n</i> (%):	
- Junior doctor	27 (29,0)
- < 5 years	19 (20,4)
- Between 5 and 10 years	15 (16,1)
- > 10 years	32 (34,4)
<i>Data are presented as median and interquartile range, unless stated otherwise</i>	

The observed ventilation data are presented in Table 2. All patients were ventilated with assist control ventilation (ACV), the median volume was 420 ml and the median RR was 16.

The median Vt was 6.45 ml/kg of PBW with 79.6% of patients having a Vt between 6 and 8 ml/kg of PBW according to the emergency physicians' estimates. According to ICU data (weight and height on arrival at the CHUGA could only be collected for 88 patients), 69.3% of patients were ventilated with a Vt considered protective.

Concerning the RR adapted to the Vt, 21.5% of patients were within the range of the Ventilo application according to the emergency doctor's estimates and 15.9% according to the ICU data. Among the 20 patients with an adapted RR to the Vt (according to emergency physicians' data), 7 are no longer considered to be ventilated as protective according to the weight and height measured in the ICU: 4 patients have a Vt lower than 6 ml/kg, 2 have a respiratory rate too high and 1 have a Vt over 8 ml/kg. One patient was initially considered non-protective with a too low Vt but becomes protected with ICU data.

ACV mode	100%	
Final volume (ml)	420 (400-450)	
RR (/min)	16 (15-20)	
	According to weight and height estimated by emergency doctor (n=93)	According to weight and height measured in the ICU (n=88)
Minute ventilation (ml/kg/min)	110 (97,8-133)	108 (93,4-132,2)
Vt (ml/kg PBW)	6,45 (6,06-7,12)	6,58 (5,9-7,24)
- < 6 ml/kg PBW, <i>n</i> (%)	14 (15)	22 (25)
- 6-8 ml/kg of PBW, <i>n</i> (%)	74 (79.6)	61 (69,3)
- > 8 ml/kg of PBW, <i>n</i> (%)	5 (5,4)	5 (5,7)
Patients within VENTILO range, <i>n</i> (%)	20 (21,5)	14 (15,9)
<i>Data are presented as median and interquartile range, unless stated otherwise</i>		

The Bland and Altman method analyses the agreement between weights and heights determined by emergency doctors and those measured in the ICU. Weight has a tendency to be overestimated by 2 kg with agreement limits of +17.1 kg to -13.3 kg (Figure 1). Height estimate varied from +13.6 cm to -15 cm but we cannot say that it is underestimated by emergency physicians because of the repartition of the values on the graph (Figure 2).

Figure 1: Concordance between weight assessed in the ED and weight measured in the ICU according to Bland-Altman representation

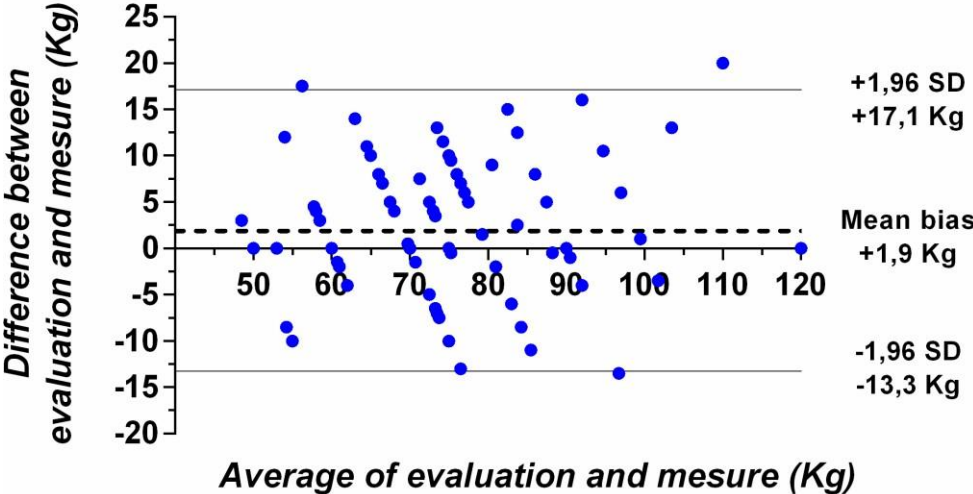
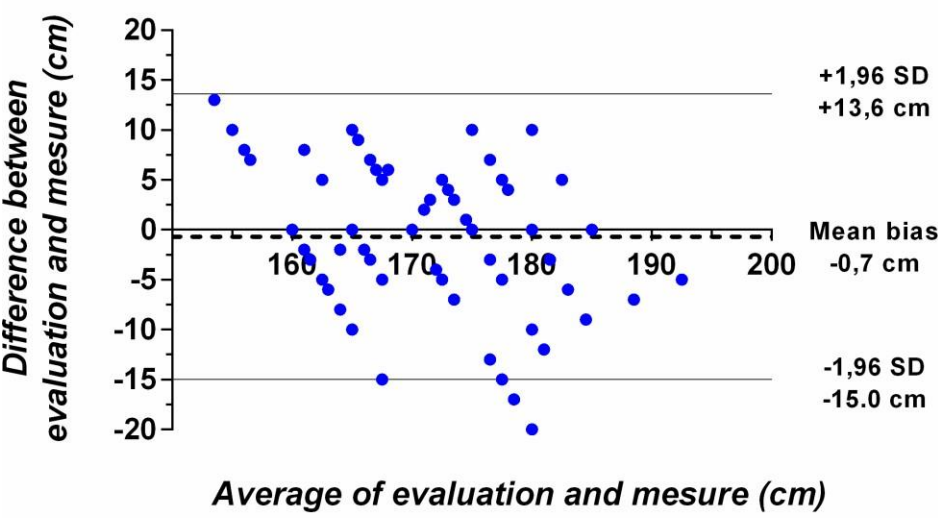


Figure 2: Concordance between height assessed in ED and height measured in the ICU according to Bland-Altman representation



Univariate analysis (table 3) shows that the RR and minute volume are significantly higher in the protective group compared to the non-protective one (median RR of 22/min and median minute volume of 144.7ml/kg/min versus 15/min and 103.8ml/kg/min). Patients in the non-protective group had a median saturation of 98% and a median PaO₂ of 126.7 mmHg (vs 95% and 99 mmHg in the other) but there was no significant difference between the two groups regarding oxygenation. Blood gases, EtCO₂ values, mortality, hospital length of stay and ventilation did not differ significantly between the two groups. In univariate analysis, the factors that may influence ventilatory settings were physician's experience, PBW and temperature. In multivariate analysis (Appendix 1), these factors were not significantly associated with non-protective ventilation.

Table 3: Comparison of variables between patients considered as protectors (for Vt and RR) and those not considered as protectors according to VENTILO (univariate analysis)			
	Protective ventilation n = 20 (21,5%)	Non-protective ventilation n = 73 (78.5%)	P value
Place of inclusion, <i>n (%)</i> :			0,75
- Pre hospital	17 (85)	58 (79)	
- ED	3 (15)	15 (20,5)	
Gender, <i>n (%)</i> :			0,19
Male	10 (50)	50 (68,5)	
Age (years)	58 (47,8-73,8)	55 (30,5-67)	0,27
Estimated weight (kg)	72,5 (66,3-86)	75 (70-80)	0,90
Estimated height (cm)	170 (160-172)	170 (165-180)	0,12
Estimated BMI	25,0 (23,4-29,8)	24,8 (22,4-27,7)	0,47
Estimated PBW (kg)	62 (52-67,8)	66 (57-75)	0,08
Temperature (°C)	36,8 (36-37,3)	36,1 (35,7-36,9)	0,13
T° < 36 °C, <i>n (%)</i>	3 (15)	18 (24,7)	0,54
T° ≥ 38°C, <i>n (%)</i>	2 (10)	0 (0)	0,04
Chronic respiratory disease, <i>n (%)</i>	0 (0)	7 (9,6)	0,3
Indication of intubation, <i>n (%)</i> :			0,84
- Neurological failure	14 (70)	50 (68,5)	1
- Cardiac arrest	5 (25)	20 (27,4)	1
- Respiratory failure	1 (5)	2 (2,7)	0,5
- Sedation for analgesic purposes	0	1 (1,4)	1

Experience of emergency physicians, <i>n</i> (%):			0,11
- Junior doctor	10 (50)	17 (23,3)	0,03
- < 5 years	4 (20)	15 (20,5)	1
- Between 5 and 10 years	1 (5)	14 (19,2)	0,18
- > 10 years	5 (25)	27 (37)	0,43
Final ventilation settings and monitoring parameters:			
- Volume (ml)	415 (400-450)	420 (400-450)	0,58
- Volume in ml /kg/min	144,7 (133,7-157)	103,8 (92,9-115,8)	<0,01
- Vt (ml/kg PIT)	6,7 (6,2-7,7)	6,4 (6-7,0)	0,16
- FR (nb of cycles/min)	22 (20-24)	15 (14-18)	<0,01
- PEEP	5 (5-5)	5 (4-5)	0,05
- FiO2 (%)	65 (40-95)	60 (45-80)	0,18
- SpO2 (%)	95 (94-98)	98 (96-99)	0,81
Initial EtCO2	43 (35-60)	40 (35-48)	0,23
Final ETCO2	39,5 (32-43,8)	36 (33-40)	0,26
Blood gases:			
- pH	7,36 (7,24-7,41)	7,35 (7,29-7,41)	0,68
- PaO2 (mmHg)	99 (81,8-207)	126,7 (85,9-196,7)	0,62
- PaCO2 (mmHg)	42 (33,4-52,9)	41 (37,7-47,7)	0,94
Data in ICU:			
- Death at first month, <i>n</i> (%)	8 (40)	31 (42,5)	1
- ICU length of stay (days)	3 (2-5,8)	3 (1-5,8)	0,63
- Days under ventilation	1,5 (1-3)	1,5 (1-3)	0,98
<i>Data are presented as median and interquartile range, unless stated otherwise</i>			

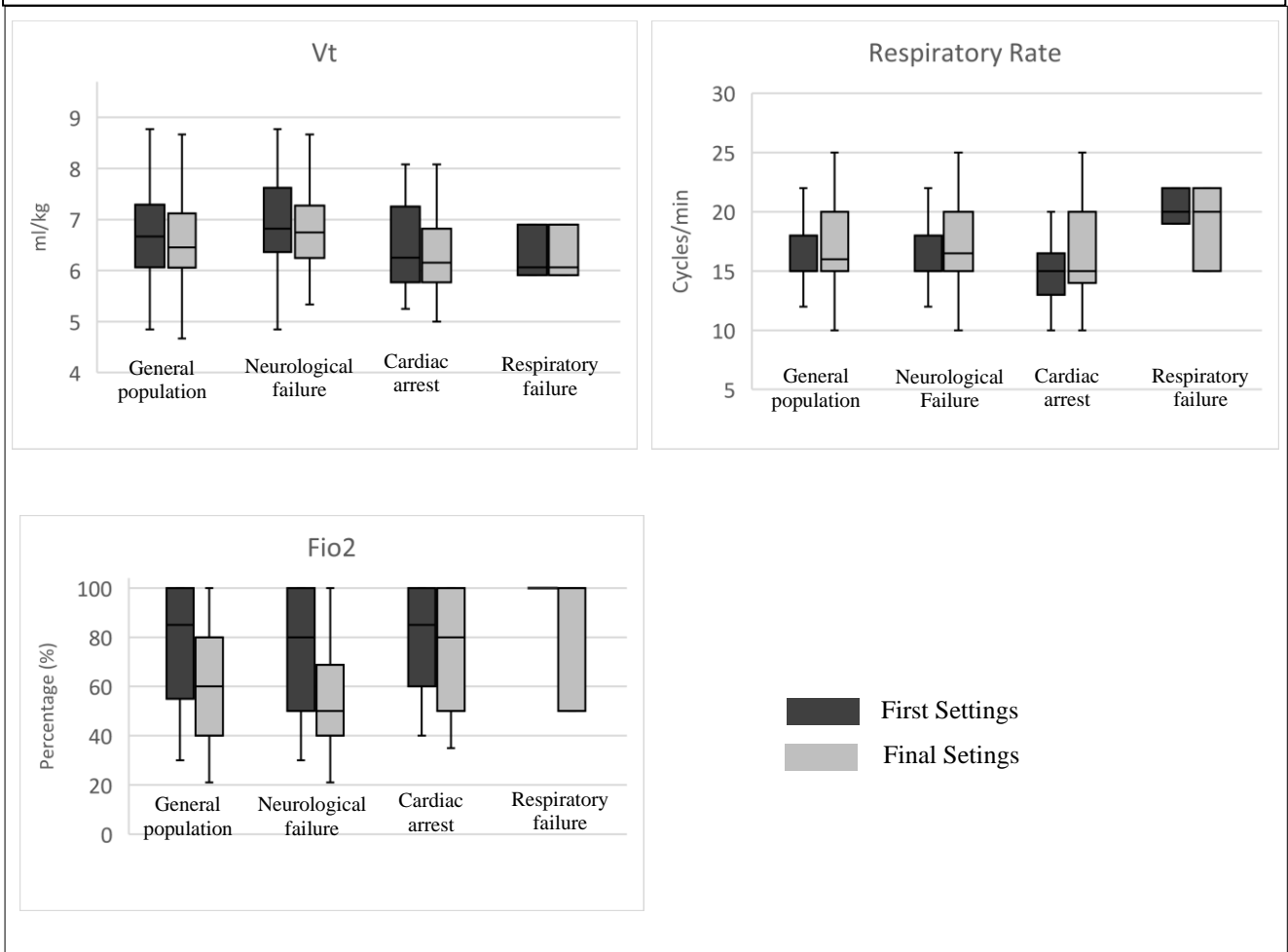
Appendix 2 shows the characteristics of patients for each indication of intubation. The population is younger in the neurological failure category (55 years versus 64 years in the cardiac arrest category and 77 years in the respiratory failure category). The inclusion of patients in cardiac arrest is mostly pre-hospital (96%). Mortality was higher in cardiac arrest (68%) and respiratory failure (66.7%) categories.

Figure 3 and Appendix 3 show the adaptation of ventilatory parameters by emergency doctors. Volume was modified for 27 patients (29%) with a decrease in 70% of cases. A change in RR occurred for 55 patients (59.1%) with an increase for 62% of them, about an average of 4 cycles per minute. Fio2 was titrated for 52.7% of patients (*n* = 49) with a decrease in 83.7% of cases.

For other ventilatory parameters, the median PEEP was 5 in all categories. PEEP was less than 5 for 31 patients at the first settings and for 23 patients at the final settings. 12 patients had a PEEP of 0 (7 in the category "neurological failure", 4 in "cardiac arrest", 1 in "respiratory failure").

Peak pressure cannot be analysed due to the low number of data collected (30 out of 93).

Figure 3: Comparison of Vt, RR and FiO2 at initiation of ventilation and at the end of emergency physician's care



Blood gases analysis are represented in Tables 3 to 4 and Appendix 4. PaO2 was above 100 mmHg for 52 patients (60%), including 20 patients with PaO2 above 200 mmHg (21.5%).

In the protective population (with an RR adapted to Vt), the median PaO2 was 99 mmHg and FiO2 was decreased for 50% of the patients. In the non-protective group, the median PaO2 was 126 mmHg and 41% of the patients had a reduction of the FiO2.

In the cardiac arrest group, the median PaO₂ was higher than in the rest of the subgroups (161.35 mmHg). A PaO₂ greater than 100 mmHg was found for 80% of patients in this population and 36% had a PaO₂ above 200 mmHg. An FiO₂ of 100% was used for 40% of the patients on arrival at hospital in this group.

For the rest of the blood gases parameters, pH was lower and PaCO₂ was higher in the cardiac arrest and respiratory failure categories.

Table 4: Initial blood gases in the ICU					
	Total population (n = 93)	Neurological failure (n = 64)	Cardiac arrest (n = 25)	Respiratory failure (n = 3)	Sedation for analgesic purposes (n=1)
pH	7,35 (7,26-7,41)	7,38 (7,31- 7,43)	7,26 (7,07-7,34)	7,22 (7,14-7,23)	7,34
PaO ₂ (mmHg)	124,85 (84,88- 196,83)	109,6 (82,85- 191,63)	161,35 (113,9- 223,65)	69 (59,6 - 123)	148,6
PaCO ₂ (mmHg)	41 (36,15 - 48,2)	39,8 (34,15-43)	47,8 (40,6-56,45)	53,2 (46,7- 82,2)	41
<i>Data are presented as median and interquartile range, unless stated otherwise</i>					

Appendix 4 shows the characteristics of patients according to their Vt. The 14 patients in the group Vt under 6 ml/kg PBW are younger (median age 45 years), taller and lighter, were intubated in 50% of cases for cardiac arrest and by doctors having an experience of less than 5 years or between 5 and 10 years.

IV. DISCUSSION

The importance of tidal volume and the risks of an elevated V_t seem to be progressively integrated into daily practice of physicians (29). The study on the ventilation of patients admitted to the ED for septic shock in 2013 (30) showed a median V_t of 8.8 ml/kg of PBW, with 27% of patients ventilated with a V_t between 6 and 8 ml/kg of PBW. In 2015, a new study in the ED (31) found 55% of patients ventilated with a protective V_t , with a median V_t of 7.6 ml/kg of PBW. A study published in 2019 (32) evaluated the evolution of practices in an emergency department: before 2014, the median V_t was 9 ml/kg of PBW and after the establishment of a protocol, V_t decreased to 7.2 ml/kg of PBW and the number of patients ventilated with a protective V_t was significantly higher (from 23% to 72%). In our study, 79.6% of patients were ventilated with a V_t between 6 and 8 ml/kg of PBW and the median V_t was 6.45 ml/kg of PBW. It can be explained by the training of emergency physicians to a protective V_t during their internship in ICU, the establishment of recommendations by the French learned societies (33) and at the local level, by protocols for the management of cardiac arrest recommending a V_t of 6 ml/kg of PBW. The errors in V_t setting can be explained by a lack of precision in the estimation of height and the calculation of a V_t based on estimated weight and not on PBW. Visual estimate was used for all patients included in this study. It is a source of important error, especially for small persons (34). The Bland and Altman representation (Figure 1 and 2) shows a tendency to overestimate weight and a large variability in height estimation (from +13.6 cm to -15 cm). Half of the population has a volume set between 400 and 450 ml (Table 2), which is more indicative of a standard volume setting, that can be applied to a large number of patients, rather than a personalised volume determined according to the predicted body weight. In our study 14 patients were ventilated with volumes under 6 ml/kg of PBW and 5 patients with V_t over 8 ml/kg of PBW (Appendix 4). It seems that doctors try to be closer to the lower limit of a protective V_t , which may lead to an underestimation of the volume needed if there is an error in the height determination. Indeed, patients with a V_t under 6 ml/kg of PBW are taller than the population ventilated with a protective V_t . Recent studies have investigated the decrease in volume between 4 and 6 ml/kg of PBW in populations without ARDS, such as the PReVENT study which found no difference in the duration of invasive ventilation, mortality or the number of lung infections (35). The use of such a volume is often associated with hypercapnic acidosis, despite the increase in RR to 40 (36), and preferably in ICU on patient having ARDS in combination with ECMO to remove CO₂ and improve oxygenation (37). This practice is not applicable to the population in the emergency.

Protective ventilation means a reduced tidal volume compared to physiological ventilation with an increased RR to limit hypercapnic acidosis which appears to be associated with higher mortality in intubated and ventilated patients (38,39). In the ICU, each adaptation of the RR is guided by the PaCO₂ which should be set between 35 and 45 mmHg (40). In this study, the percentage of patients ventilated with a protective V_t and an adapted RR (according to VENTILO application) is 21.5% (20 patients). The respiratory rate is too low for 86% of the patients in the non-protective group (63 out of 73 patients, Table 3). Physicians often choose standard settings with a RR about 15 or 16 cycles per minute, close to the physiological RR, without personalisation or adaptation to the use of a reduced V_t. In Table 3, we initially thought that young doctors had a tendency to be better trained in protective ventilation but there was no significant difference in multivariate analysis (Appendix 1). One of the biases is that emergency doctors are often escorted by a resident, it could explain a double focus on ventilator settings favoring a protective V_t and RR.

EtCO₂ is the only monitoring parameter in pre-hospital to estimate PaCO₂. The final EtCO₂ in the protective group was 39.5 mmHg and 36 mmHg in the non-protective group but there was no significant difference on PaCO₂ (respectively 42 mmHg and 41 mmHg, Table 3). We expected a higher PaO₂ in the second group as the RR was lower for most patients. These results may be explained by the small number of patients included in the study and by the fact that we recorded the first blood gases in the medical file without knowing the time between their analysis and the patient's entry into the ICU and whether the settings of the ventilator were changed. We can notice a gradient between the final EtCO₂ and PaCO₂ in each group with PaCO₂ on average 5 mmHg higher than EtCO₂, with an important variability between -16 and + 46 mmHg (Tables 3 and 4, Appendix 4). Some studies have shown that there is a good correlation between EtCO₂ and PaCO₂ (41, 42). The gradient is evaluated between 2 and 5 mmHg in healthy people intubated for a surgery (43), but it can be around 20 mmHg (44) in respiratory failure, explained by the dead space effect and ventilation/perfusion disorders. EtCO₂ in invasive ventilation is often described to underestimate PaCO₂ (45), other studies in pre-hospital ventilated patients showed that the EtCO₂-PaCO₂ gradient can vary widely (46). The estimation of PaCO₂ by EtCO₂ in the practice of emergency medicine has limitations and the frequent lower values of EtCO₂ in comparison to PaCO₂ could induce an inappropriate decrease in RR by the emergency physician.

Other ventilatory parameters were analysed. We used the LOV-ED protocol (24) to determine the secondary endpoints of PEEP and oxygen saturation. PEEP under 5 was used in 33% of the population and 12 patients had a PEEP equal to 0 while animal models have demonstrated the risks for the lung parenchyma of zero PEEP (14). The majority of patients with a PEEP of 0 were included on neurological criteria (7 patients out of 12) with suspected intracranial bleeding. This practice is probably based on the idea that a positive PEEP might change intracranial pressure in patients with cerebral disorders because of the reduced venous return and the increased intrathoracic pressure. Zero PEEP is gradually disappearing from practice (29) and recent recommendations for brain damaged patients suggest to apply a similar PEEP to the one used in patients without brain damages (40). A PEEP of 5 limits atelectasis, promote better oxygenation and reduce infectious pulmonary complications of ventilation (47,48). It should be raised in the case of obesity because of the intra-abdominal pressure which reduces pulmonary compliance and increases the risk of atelectasis (49).

Oxygen titration is also important in ventilation. A saturation of 90-95% is currently recommended for the majority of patients (50) as well as a PaO₂ target of 70 to 100 mmHg since too much oxygen increases mortality in the ICU (51, 52). However, at initial management in our study, 48% of patients had a FiO₂ of 100% (45 patients). FiO₂ titration was performed for 49 patients (52.7%) with a decrease in 83.7% of cases (Figure 3). Majority of patients were hyperoxygenated on the blood gases since the median PaO₂ is 124.85 mmHg (IQR 84.88-196.83). This highlights that the deleterious effects of hyperoxia (53, 54) are probably unknown. The median saturation and median PaO₂ are closer to the targets in the protective group than in the non-protective group (95% and 99 mmHg compared to 98% and 126.7 mmHg) but there is no significant difference. In the cardiac arrest group, the PaO₂ is greater than 100 mmHg for 80% of patients (with a maximum of 560 mmHg) while cerebral and cardiac deleterious effects are described (55). A recent study investigating the provision of oxygen in cardiac arrest, showed no significant difference in mortality between a PaO₂ target of 68 to 75 mmHg versus a higher PaO₂ of 98 to 105 mmHg (56). According to the EXACT study (57), there was no better survival at discharge from the hospital between patients having a cardiac arrest in pre-hospital oxygenated with targets of saturation about 90-94% or 98-100%. However, there was a greater risk of desaturation below 90% and of a new hypoxic cardiac arrest in the first group. Oxygen targets in mechanical ventilation are more and more questioned (58) and further studies seem necessary to define saturation targets in order not to be harmful for patients.

Patients in the non-protective ventilation category are more hypothermic (Table 3) and 5 patients were not considered to be protective because of a too high RR. In the case of hypothermia, the basic metabolism is reduced, the production of CO₂ decreases, a respiratory alkalosis appears (27, 59) and a reduction in RR is appropriate to maintain the acid-base balance. The situation is reversed in hyperthermia with an increased basal metabolism. These notions seem to be unknown by emergency physicians, applications such VENTILO can help with ventilator settings as it integrates this parameter.

The results on mortality, duration of ventilation and length of stay in the ICU showed no significant difference between the groups protector and non-protector. Mortality was very high in the study with 42% of deaths at first month, it was higher in cardiac arrest and respiratory failure groups. Most of these patients were included in pre-hospital, reflecting their severity. Priorities in pre-hospital are probably not on optimisation of ventilation settings and this is an element to be taken into account in this study.

Limitations

The study is monocentric, taking place in a single hospital. There are local recommendations on ventilation for cardiac arrest and covid patients that may influence some settings. For example, a RR of 15 is recommended for cardiac arrest to avoid hyperventilation and a PEEP of 0 during chest compression which is probably not changed after recovery. However, we have no reason to believe that our practices are different from other hospitals in France.

The population is small and unrepresentative: there are only 3 patients included on respiratory criteria and none of the patients had Covid 19. This can be explained by the possibility of using alternative therapies such as non-invasive ventilation in some cases.

Concerning the biases, this is an observational study and we used a data collection sheet to get information, it can be exposed to a bias of declaration, in particular of memorisation. To avoid this, it would have been preferable to recover the settings directly from the respirators, but they are not equipped with a saving option. The Hawthorne effect applies, the teams were aware of the study proceedings and they probably took greater care and motivation to the settings. To avoid this, we did not explain which parameters were part of the primary endpoint, nor the use of VENTILO.

We were also exposed to missing data, particularly for temperature which was not filled in for 20% of the patients or for peak pressure which was measured for only a third of the population. It would have been more appropriate to measure plateau pressure rather than peak pressure but it is complicated with transport ventilators.

Concerning the data collected at the hospital, weight and height measured on arrival in ICU were taken as a reference value and found in the patients' computer files. It could not be collected for 5 patients and for the calculation of the concordance of weight and height, we had to impute these missing data with those measured by the emergency physicians. We also do not know the accuracy of these values as we do not know how they were measured in the hospital.

Finally, the results of the first blood gases were taken from the patients' computer file but we do not know when they were collected exactly and whether any changes in ventilatory settings occurred. In addition, 7 patients were quickly limited in terms of treatment by the severity of their clinical condition and blood gases were not analysed for them.

V. CONCLUSION

In this study we observed a majority use of protective tidal volume at the initiation of emergency mechanical ventilation. It seems to be based on a standard attitude and not on the assessment of the predicted body weight. Adaptation of the respiratory rate is insufficiently performed. Personalisation of ventilation is necessary for each patient and the use of dedicated applications could allow a better management of patients in the initial phase of ventilation.

THÈSE SOUTENUE PAR : ODO ALEXANDRA

TITRE :

VENTILATION INVASIVE INITIÉE EN MÉDECINE D'URGENCE :

ETUDE PROSPECTIVE MONOCENTRIQUE AU CHU DE GRENOBLE

Résultats finaux de l'Etude AREVISS : Analyse des Réglages Ventilatoires Initiés par l'équipe du Samu ou du SAU

CONCLUSION :

Nous avons observé dans cette série une utilisation majoritaire du volume courant protecteur à l'initiation d'une ventilation mécanique d'urgence. Cela semble basé sur une attitude standard et non sur l'évaluation du poids idéal théorique. L'adaptation de la fréquence respiratoire est insuffisamment réalisée. Une personnalisation de la ventilation est nécessaire pour chaque patient et l'utilisation d'applications dédiées pourrait permettre une meilleure prise en charge des patients à la phase initiale de la ventilation.

VU ET PERMIS D'IMPRIMER

Grenoble, le : 21/03/23

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BIBLIOGRAPHIE

1. Adnet F, Jouriles NJ, Toumelin PL, Hennequin B, Taillandier C, Rayeh F, et al. Survey of Out-of-hospital Emergency Intubations in the French Prehospital Medical System: A Multicenter Study. *Ann Emerg Med.* 32(4):454-60.
2. Higgs, A., McGrath, B.A., Goddard, C., Rangasami, J., Suntharalingam, G., Gale, R., Cook, T.M., 2018. Guidelines for the management of tracheal intubation in critically ill adults. *Br. J. Anaesth.* 120, 323–352.
3. Monet, C., De Jong, A., Jaber, S., 2021. Intubation in the ICU. *Anaesth. Crit. Care Pain Med.* 40, 100916.
4. Desmettre, T., Kepka, S., Piton, G., Khoury, A., Capellier, G., n.d. Quel mode ventilatoire pour quelle détresse respiratoire ? 11.
5. Weingart, S.D., 2016. Managing Initial Mechanical Ventilation in the Emergency Department. *Ann. Emerg. Med.* 68, 614–617.
6. Coleman, M.H., Aldrich, J.M., 2021. Acute Respiratory Distress Syndrome. *Crit. Care Clin.* 37, 851–866.
7. Slutsky, A.S., 2015. History of Mechanical Ventilation. From Vesalius to Ventilator-induced Lung Injury. *Am. J. Respir. Crit. Care Med.* 191, 1106–1115.
8. Dreyfuss D, Saumon G. Ventilator-induced lung injury: lessons from experimental studies. *Am J Respir Crit Care Med.* janv 1998;157(1):294-323.
9. Brochard L, Roudot-Thoraval F, Roupie E, Delclaux C, Chastre J, Fernandez-Mondéjar E, et al. Tidal Volume Reduction for Prevention of Ventilator-induced Lung Injury in Acute Respiratory Distress Syndrome. *Am J Respir Crit Care Med.* 1 déc 1998;158(6):1831-8.
10. Gajic O, Dara SI, Mendez JL, Adesanya AO, Festic E, Caples SM, et al. Ventilator-associated lung injury in patients without acute lung injury at the onset of mechanical ventilation. *Crit Care Med.* sept 2004;32(9):1817-24. 32
11. Gajic O, Frutos-Vivar F, Esteban A, Hubmayr RD, Anzueto A. Ventilator settings as a risk factor for acute respiratory distress syndrome in mechanically ventilated patients. *Intensive Care Med.* juill 2005;31(7):922-6.
12. Acute Respiratory Distress Syndrome Network, Brower RG, Matthay MA, Morris A, Schoenfeld D, Thompson BT, et al. 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.* 04 2000;342(18):1301-8
13. Fuller BM, Mohr NM, Drewry AM, Carpenter CR. Lower tidal volume at initiation of mechanical ventilation may reduce progression to acute respiratory distress syndrome: a systematic review. *Crit Care Lond Engl.* 18 janv 2013;17(1):R11.
14. Webb HH, Tierney DF. Experimental pulmonary edema due to intermittent positive pressure ventilation with high inflation pressures. Protection by positive end-expiratory pressure. *Am Rev Respir Dis.* nov 1974;110(5):556-65.

15. Goyal M, Houseman D, Johnson NJ, Christie J, Mikkelsen ME, Gaieski DF. Prevalence of acute lung injury among medical patients in the emergency department. *Acad Emerg Med Off J So Acad Emerg Med.* sept 2012;19(9):E1011-1018.
16. Bellani, G., Laffey, J.G., Pham, T., Fan, E., Brochard, L., Esteban, A., Gattinoni, L., van Haren, F., Larsson, A., McAuley, D.F., Ranieri, M., Rubenfeld, G., Thompson, B.T., Wrigge, H., Slutsky, A.S., Pesenti, A., for the LUNG SAFE Investigators and the ESICM Trials Group, 2016. Epidemiology, Patterns of Care, and Mortality for Patients With Acute Respiratory Distress Syndrome in Intensive Care Units in 50 Countries. *JAMA* 315, 788.
17. Lellouche F, Lipes J. Prophylactic protective ventilation : lower tidal volumes for all critically ill patients? *Intensive Care Med.* janv 2013;39(1):6-15.
18. Determann RM, Royakkers A, Wolthuis EK, Vlaar AP, Choi G, Paulus F, 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 Lond Engl.* 2010;14(1):R1.
19. Neto AS, Simonis FD, Barbas CSV, Biehl M, Determann RM, Elmer J, et al. Lung-Protective Ventilation With Low Tidal Volumes and the Occurrence of Pulmonary Complications in Patients Without Acute Respiratory Distress Syndrome: A Systematic Review and Individual Patient Data Analysis. *Crit Care Med.* oct 2015;43(10):2155-63.
20. Serpa Neto A, Cardoso SO, Manetta JA, Pereira VGM, Espósito DC, Pasqualucci M de OP, et al. Association between use of lung-protective ventilation with lower tidal volumes and clinical outcomes among patients without acute respiratory distress syndrome: a meta-analysis. *JAMA.* 24 oct
21. Needham DM, Yang T, Dinglas VD, Mendez-Tellez PA, Shanholtz C, Sevransky JE, et al. Timing of low tidal volume ventilation and intensive care unit mortality in acute respiratory distress syndrome. A prospective cohort study. *Am J Respir Crit Care Med.* 15 janv 2015;191(2):177-85.
22. Gao CA, Howard FM, Siner JM, Candido TD, Ferrante LE. Lung-Protective Ventilation Over 6 Years at a Large Academic Medical Center: An Evaluation of Trends, Adherence, and Perceptions of Benefit. *Crit Care Explor.* janv 2021;3(1):e0325.
23. Lellouche F, Delorme M, Brochard L. Impact of Respiratory Rate and Dead Space in the Current Era of Lung Protective Mechanical Ventilation. *Chest.* juill 2020;158(1):45-7
24. Fuller BM, Ferguson IT, Mohr NM, Drewry AM, Palmer C, Wessman BT, et al. Lung-Protective Ventilation Initiated in the Emergency Department (LOV-ED): A Quasi-Experimental, Before-After Trial. *Ann Emerg Med.* sept 2017;70(3):406-418.e4.
25. Stoltze AJ, Wong TS, Harland KK, Ahmed A, Fuller BM, Mohr NM. Prehospital tidal volume influences hospital tidal volume: A cohort study. *J Crit Care.* 1 juin 2015;30(3):495-501.
26. Radford, E.P., Ferris, B.G., Kriete, B.C., 1954. Clinical Use of a Nomogram to Estimate Proper Ventilation during Artificial Respiration. *N. Engl. J. Med.* 251, 877–884.

27. Polderman, K.H., 2009. Mechanisms of action, physiological effects, and complications of hypothermia: *Crit. Care Med.* 37, S186–S202.
28. Fuller BM, Mohr NM, Miller CN, Deitchman AR, Levine BJ, Castagno N, et al. Mechanical Ventilation and ARDS in the ED: A Multicenter, Observational, Prospective, Cross-sectional Study. *Chest.* août 2015;148(2):365-74
29. Schaefer MS, Serpa Neto A, Pelosi P, Gama de Abreu M, Kienbaum P, Schultz MJ, et al. Temporal Changes in Ventilator Settings in Patients With Uninjured Lungs: A Systematic Review. *Anesth Analg.* juill 2019;129(1):129-40
30. Fuller BM, Mohr NM, Dettmer M, Kennedy S, Cullison K, Bavolek R, et al. Mechanical ventilation and acute lung injury in emergency department patients with severe sepsis and septic shock: an observational study. *Acad Emerg Med Off J Soc Acad Emerg Med.* juill 2013;20(7):659-69
31. Fuller BM, Mohr NM, Miller CN, Deitchman AR, Levine BJ, Castagno N, et al. Mechanical Ventilation and ARDS in the ED: A Multicenter, Observational, Prospective, Cross-sectional Study.
32. Prekker, M.E., Donelan, C., Ambur, S., Driver, B.E., O'Brien-Lambert, A., Hottinger, D.G., Adams, A.B., 2020. Adoption of low tidal volume ventilation in the emergency department: A quality improvement intervention. *Am. J. Emerg. Med.* 38, 763–767.
33. Eghiaian, A., Bazin, J., Bourgain, J., Combes, X., Jaber, S., Michelet, P., Panczer, M., Gaulain, K.N., n.d. Socle de connaissances sur les respirateurs (réanimation et urgences) et les machines d'anesthésie 60.
34. Bojmehrani A, Bergeron-Duchesne M, Bouchard C, Simard S, Bouchard P-A, Vanderschuren A, et al. Comparison of usual and alternative methods to measure height in mechanically ventilated patients: potential impact on protective ventilation. *Respir Care.* Juill 2014;59(7):1025-33.
35. Simonis, F.D., Serpa Neto, A., Binnekade, J.M., Braber, A., Bruin, K.C.M., Determann, R.M., Goekoop, G.-J., Heidt, J., Horn, J., Innemee, G., de Jonge, E., Juffermans, N.P., Spronk, P.E., Steuten, L.M., Tuinman, P.R., de Wilde, R.B.P., Vriens, M., Gama de Abreu, M., Pelosi, P., Schultz, M.J., 2018. Effect of a Low vs Intermediate Tidal Volume Strategy on Ventilator-Free Days in Intensive Care Unit Patients Without ARDS. *JAMA* 320, 1872–1880.
36. Richard, J.C., Marque, S., Gros, A., Muller, M., Prat, G., Beduneau, G., Quenot, J.P., Dellamonica, J., Taponnier, R., Soum, E., Bitker, L., Richecoeur, J., REVA research network, 2019. Feasibility and safety of ultra-low tidal volume ventilation without extracorporeal circulation in moderately severe and severe ARDS patients. *Intensive Care Med.* 45, 1590–1598.
37. Worku, E., Brodie, D., Ling, R.R., Ramanathan, K., Combes, A., Shekar, K., 2022. Venovenous extracorporeal CO2 removal to support ultraprotective ventilation in moderate-severe acute respiratory distress syndrome: A systematic review and meta-analysis of the literature. *Perfusion* 2676591221096225.

38. Tiruvoipati R, Pilcher D, Buscher H, Botha J, Bailey M. Effects of Hypercapnia and Hypercapnic Acidosis on Hospital Mortality in Mechanically Ventilated Patients. *Crit Care Med.* Juill 2017;45(7):e649-56.
39. Tiruvoipati R, Pilcher D, Botha J, Buscher H, Simister R, Bailey M. Association of Hypercapnia and Hypercapnic Acidosis With Clinical Outcomes in Mechanically Ventilated Patients With Cerebral Injury. *JAMA Neurol.* 1 juill 2018;75(7):818-26.
40. Robba C, Poole D, McNett M, Asehnoune K, Bösel J, Bruder N, et al. Mechanical ventilation in patients with acute brain injury: recommendations of the European Society of Intensive Care Medicine consensus. *Intensive Care Med.* déc 2020;46(12):2397-410
41. Razi E, Moosavi GA, Omid K, Khakpour Saebi A, Razi A. Correlation of End-Tidal Carbon Dioxide with Arterial Carbon Dioxide in Mechanically Ventilated Patients. *Arch Trauma Res.* 2012;1(2):58-62.
42. Wang, J., Zhang, J., Liu, Y., Shang, H., Peng, L., Cui, Z., 2021. Relationship between end-tidal carbon dioxide and arterial carbon dioxide in critically ill patients on mechanical ventilation. *Medicine (Baltimore)* 100, e26973.
43. Fletcher, R., Jonson, B., 1984. Deadspace and the single breath test for carbon dioxide during anaesthesia and artificial ventilation. Effects of tidal volume and frequency of respiration. *Br. J. Anaesth.* 56, 109–119.
44. Enomoto, T., Matsuda, Y., Adachi, Y., Kouno, S., Inagaki, Y., Azuma, K., Katayama, K., Takeuchi, N., Inoue, Y., 2021. Limitations of End-Tidal CO₂ Measured with a Portable Capnometer to Estimate PaCO₂ for Patients with Respiratory Disease. *Turk. Thorac. J.* 22, 212–216.
45. Nassar, B.S., Schmidt, G.A., 2017. Estimating Arterial Partial Pressure of Carbon Dioxide in Ventilated Patients: How Valid Are Surrogate Measures? *Ann. Am. Thorac. Soc.* 14, 1005–1014.
46. Belpomme V, Ricard-Hibon A, Devoir C, Dileseigres S, Devaud M-L, Chollet C, et al. Correlation of arterial PCO₂ and PETCO₂ in prehospital controlled ventilation. *Am J Emerg Med.* Nov 2005;23(7):852-9.
47. Slutsky AS, Ranieri VM. Ventilator-Induced Lung Injury. *N Engl J Med.* 28 nov 2013;369(22):2126-36.
48. Manzano F, Fernández-Mondéjar E, Colmenero M, Poyatos ME, Rivera R, Machado J, et al. Positive-end expiratory pressure reduces incidence of ventilator-associated pneumonia in nonhypoxemic patients. *Crit Care Med.* août 2008;36(8):2225-31.
49. De Jong, A., Wrigge, H., Hedenstierna, G., Gattinoni, L., Chiumello, D., Frat, J.-P., Ball, L., Schetz, M., Pickkers, P., Jaber, S., 2020. How to ventilate obese patients in the ICU. *Intensive Care Med.* 46, 2423–2435.

50. Siemieniuk RAC, Chu DK, Kim LH-Y, Güell-Rous M-R, Alhazzani W, Soccia PM, et al. Oxygen therapy for acutely ill medical patients: a clinical practice guideline. *BMJ*. 24 oct 2018;363:k4169.
51. Girardis M, Busani S, Damiani E, Donati A, Rinaldi L, Marudi A, et al. Effect of Conservative vs Conventional Oxygen Therapy on Mortality Among Patients in an Intensive Care Unit: The Oxygen-ICU Randomized Clinical Trial. *JAMA*. 18 oct 2016;316(15):1583-9.
52. Chu DK, Kim LH-Y, Young PJ, Zamiri N, Almenawer SA, Jaeschke R, et al. Mortality and morbidity in acutely ill adults treated with liberal versus conservative oxygen therapy (IOTA): a systematic review and meta-analysis. *Lancet Lond Engl*. 28 avr 2018;391(10131):1693-705.
53. Kallet RH, Matthay MA. Hyperoxic Acute Lung Injury. *Respir Care*. janv 2013;58(1):123-41.
54. Demiselle, J., Radermacher, P., Asfar, P., 2019. Hyperoxie en réanimation. *Anesth. Réanimation* 5, 91–97.
55. Llitjos, J.-F., Cariou, A., 2018. Effets de l'hyperoxie sur le pronostic après un arrêt cardiaque. *Médecine Intensive Réanimation* 27, 133–142.
56. Schmidt, H., Kjaergaard, J., Hassager, C., Mølstrøm, S., Grand, J., Borregaard, B., Roelsgaard Obling, L.E., Venø, S., Sarkisian, L., Mamaev, D., Jensen, L.O., Nyholm, B., Høfsten, D.E., Josiassen, J., Thomsen, J.H., Thune, J.J., Lindholm, M.G., Stengaard Meyer, M.A., Winther-Jensen, M., Sørensen, M., Frydland, M., Beske, R.P., Frikke-Schmidt, R., Wiberg, S., Boesgaard, S., Lind Jørgensen, V., Møller, J.E., 2022. Oxygen Targets in Comatose Survivors of Cardiac Arrest. *N. Engl. J. Med.* 387, 1467–1476.
57. Bernard, S.A., Bray, J.E., Smith, K., Stephenson, M., Finn, J., Grantham, H., Hein, C., Masters, S., Stub, D., Perkins, G.D., Dodge, N., Martin, C., Hopkins, S., Cameron, P., EXACT Investigators, 2022. Effect of Lower vs Higher Oxygen Saturation Targets on Survival to Hospital Discharge Among Patients Resuscitated After Out-of-Hospital Cardiac Arrest: The EXACT Randomized Clinical Trial. *JAMA* 328, 1818–1826.
58. Semler, M.W., Casey, J.D., Lloyd, B.D., Hastings, P.G., Hays, M.A., Stollings, J.L., Buell, K.G., Brems, J.H., Qian, E.T., Seitz, K.P., Wang, L., Lindsell, C.J., Freundlich, R.E., Wanderer, J.P., Han, J.H., Bernard, G.R., Self, W.H., Rice, T.W., PILOT Investigators and the Pragmatic Critical Care Research Group, 2022. Oxygen-Saturation Targets for Critically Ill Adults Receiving Mechanical Ventilation. *N. Engl. J. Med.* 387, 1759–1769.
59. Briot, R., Brun, J., Debaty, G., Koch, F.-X., Torres, J.-P., Bach, V., Albaladejo, P., Danel, V., 2010. Prise en charge d'un malade en hypothermie accidentelle. *Réanimation* 19, 607–615.

APPENDICES

Appendix 1, Table 1: Comparison of variables between patients considered as protectors with VENTILO (for Vt and RR) and those not considered as protectors (multivariate analysis)				
	Protective ventilation n =20 (21.5%)	Non-protective ventilation n = 73 (78,5%)	P value	Odds ratio
Physician's experience, <i>n (%)</i> :				
Junior doctor	10 (50)	17 (23,3)	Reference	Reference
1 to 5 years	4 (20)	15 (20,5)	0,44	0,58 (0,14-2,35)
5 to 10 years	1 (5)	14 (19,2)	0,08	0,14 (0,02-1,29)
> 10 years	5 (25)	27 (37)	0,22	0,43 (0,12-1,63)
Predicted body weight, <i>n (%)</i> :				
< 57 kg	7 (35)	11 (15,1)	Reference	Reference
57 to 66 kg	7 (35)	30 (41,1)	0,60	1,45 (0,35-5,81)
67 to 71 kg	3 (15)	12 (16,4)	0,99	1,02(0,19-5,51)
> 71 kg	3 (15)	20 (27,4)	0,61	0,65 (0,13-3,28)
Temperature, <i>n (%)</i> :				
36 to 38°C	15 (75)	55 (75,3)	Reference	Reference
< 36 °C	3 (15)	18 (24,7)	0,51	0,62
> 38 °C	2 (10)	0 (0)	0,99	3,2 e+7
<i>Data are presented as median and interquartile range, unless stated otherwise</i>				

Appendix 2, Table 2: Comparison of variables between patients according to their indication of intubation				
	Neurological failure (n = 64)	Cardiac arrest (n = 25)	Respiratory failure (n=3)	Sedation for analgesic purposes (n=1)
Place of inclusion, <i>n (%)</i> :				
- Pre-hospital	49 (76,6)	24 (96)	1 (33,3)	1 (100)
- ED	15 (23,4)	1 (4)	2 (66,6)	0 (0)
Gender, <i>n (%)</i> :				
Male	37 (57,8)	19 (76)	3 (100)	1 (100)
Age (years)	55 (29,5-66,75)	64 (44-76)	77 (46-83)	20
Weight (kg)	70 (70-80)	75 (70-90)	65 (60-75)	85
Height (cm)	170 (165-175)	170 (168-180)	170 (165-175)	185
BMI	25,7 (22,7-27,8)	24,7 (24,1-27,8)	23,9 (20,8-24,5)	24,8
PBW (kg)	66 (57-71)	66 (61,5-75)	66 (61-71)	80

Temperature (°C)	36,6 (35,75-37)	36 (35,2-36,9)	36 (36-37)	36,7
T° < 36 °C, n (%)	14 (21,9)	7 (28)	0 (0)	0 (0)
T° ≥ 38°C, n (%)	1 (1,6)	1 (4)	0 (0)	0 (0)
Chronic respiratory disease, n (%)	3 (4,7)	2 (8)	2 (66,7)	0 (0)
Experience of the doctor, n (%):				
- Junior doctor	20 (31,3)	7 (28)	0 (0)	0 (0)
- Senior < 5 years	13 (20,3)	4 (16)	2 (66,7)	0 (0)
- Senior between 5 and 10 years	10 (15,6)	4 (16)	1 (33,3)	0 (0)
- Senior > 10 years	21 (32,8)	10 (40)	0 (0)	1 (100)
Data in ICU:				
- Death at first month, n (%)	20 (31,3)	17 (68)	2 (66,7)	0 (0)
- ICU length of stay (days)	2,5 (2-5)	3,5 (1-7)	1 (1-16)	3
- Days under ventilation	1 (1-3)	2 (1-6,25)	1 (1-5)	1
<i>Data are presented as median and interquartile range, unless stated otherwise</i>				

Appendix 3, Table 3 : Changes in ventilatory parameters by the emergency physician and monitoring values


	Total population (n = 93)		Neurological failure (n = 64)		Cardiac arrest (n = 25)		Respiratory failure (n = 3)	
	1st settings	Final settings	1st settings	Final settings	1st settings	Final settings	1st settings	Final settings
Volume(ml)	430 (400-465)	420 (400-450)	445 (400-480)	425 (400-450)	420 (400-450)	420 (400-450)	390 (370-490)	390 (370-490)
Vt (ml/kg/min)	6,66 (6,06-7,29)	6,45 (6,06-7,12)	6,82 (6,36-7,62)	6,76 (6,24-7,27)	6,27 (6-7,25)	6,15 (5,76-6,82)	6,06 (5,91-6,90)	6,06 (5,91-6,90)
RR	15 (15-18)	16 (15-20)	15 (25-19)	16,5 (15-20)	15(13-16,5)	15 (14-20)	20 (19-22)	20 (15-22)
PEEP	5 (4-5)	5 (4-5)	5 (4-5)	5 (5-5)	5 (3,5 - 5)	5 (4-5)	5 (0-5)	5 (0-5)
FiO2	85 (55-100)	60 (40-80)	80 (50-100)	50 (40-68,75)	85 (60-100)	80 (50-100)	100 (100-100)	75 (50-100)
SPO2	99 (96-100)	97 (95-99)	99 (97-100)	97 (95-99)	97 (95,5-100)	97,5 (95-99)	90 (75-92)	91 (90-94)
EtCO2	40,5 (35-50)	36 (33-40,25)	40 (35-47,25)	37 (33-40)	42,5 (35-57)	36 (33-45)	37 (27-50)	34 (30-37)
Peak pressure	22 (18-25,25)	21 (18-25)	22 (18-25)	21 (18-25)	/	/	/	/
/ : not enough data * Peak pressure: only 30 responses out of 93								

Appendix 4, Table 4: Comparison of variables between patients ventilated with a protective Vt [6-8 ml/kg PBW] versus a non-protective Vt

	Vt [6-8 ml/kg PBW] N = 74 (79,6%)	Vt < 6ml/kg PBW N = 14 (15%)	Vt > 8 ml/kg PBW N = 5 (5,4%)
Place of inclusion, n (%):			
- Pre-hospital	61 (82,4)	11 (78,6)	3 (60)
- ED	13 (17,6)	3 (21,4)	2 (40)
Gender, n (%):			
Male	44 (59,5)	14 (100)	2 (40)
Age (years)	55,5 (31-67)	45 (26,25-79,5)	69 (58,5-76)
Weight (kg)	75 (70-81,25)	70 (60-81,25)	70 (65-85)
Height (cm)	1,7 (1,65-1,75)	1,75 (1,7-1,8)	1,6 (1,6-1,7)
BMI	25,5 (23,4-27,8)	23,1 (20,7-26,2)	27,3 (25,4-29,5)
PBW (kg)	66 (57-71)	71 (66-75)	52 (52-66)
Temperature (°C)	36,2 (35,8-36,9)	36,5 (35,2-37)	37 (34,5-37)
T° < 36 °C, n (%)	16 (21,6)	4 (28)	1 (20)
T° ≥ 38°C, n (%)	2 (2,7)	0 (0)	0 (0)
Chronic respiratory disease, n (%)	5 (6,8)	2 (14,3)	0 (0)
Indication of intubation, n (%):			
- Neurological failure	53 (71,6)	6 (42,9)	5 (100)
- Cardiac arrest	18 (24,3)	7 (50)	0 (0)
- Respiratory failure	2 (2,7)	1 (7,1)	0 (0)
- Sedation analgesia	1 (1,4)	0 (0)	0 (0)
Experience of the doctor, n (%):			
- Junior doctor	24 (32,4)	2 (14,2)	1 (20)
- < 5 years	13 (17,6)	6 (42,9)	0 (0)
- Between 5 and 10 years	10 (13,5)	4 (28,6)	1 (20)
- > 10 years	27 (36,5)	2 (14,3)	3 (60)
Initial EtCO2	41 (35 -48)	43 (31-57,5)	33 (29-37,5)
Final ETCO2	36 (33-40)	37 (34-56,5)	33 (32-38,5)
Blood gases:			
- pH	7,35 (7,26 - 7,41)	7,33 (7,19-7,46)	7,37 (7,31-7,45)
- PaO2 (mmHg)	140,6 (84,6-199,9)	115,6 (93,8-190,9)	98,5 (73,8-110,8)
- PaCO2 (mmHg)	41 (35,9 - 47,95)	39,8 (33,43-57,03)	42,65 (37,78-51,35)
Data in ICU:			
- Death at first month, n (%)	28 (37,8)	8 (57,1)	3 (40)
- ICU length of stay (days)	3 (2- 5,25)	2 (0,75-11,5)	2 (1,13-13)
- Days under ventilation	1,5 (1-3)	2 (0,6-6,5)	1 (0,55-3)

Data are presented as median and interquartile range, unless stated otherwise

DATA COLLECTION SHEET

	Analyse des réglages ventilatoires initiés par l'équipe du SAMU ou du SAU	Etude AREVISS
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Date : ___ / ___ / ___

Lieu de prise en charge : SAMU SAU

Patient : NOM: _____ PRENOM : _____ Date de Naissance : ___ / ___ / ___

CRITERES D'INCLUSION		CRITERES D'EXCLUSION	
Age \geq 18 ans	<input type="checkbox"/> OUI <input type="checkbox"/> NON	Personne protégée (art. L1121-5 à L1121-8 du CSP)	<input type="checkbox"/> OUI <input type="checkbox"/> NON
Sous ventilation mécanique invasive	<input type="checkbox"/> OUI <input type="checkbox"/> NON	Patient décédé avant l'admission dans un service du CHU de Grenoble	<input type="checkbox"/> OUI <input type="checkbox"/> NON
Ventilation initiée par un médecin du SAMU ou des urgences	<input type="checkbox"/> OUI <input type="checkbox"/> NON	Ventilation initiée par un médecin extérieur au SAMU ou aux urgences	<input type="checkbox"/> OUI <input type="checkbox"/> NON
Transfert au CHU de Grenoble	<input type="checkbox"/> OUI <input type="checkbox"/> NON	Admission extérieure au CHU de Grenoble	<input type="checkbox"/> OUI <input type="checkbox"/> NON

Indication de l'IOT : Défaillance neurologique Défaillance respiratoire
 ACR Sédation à visée analgésique
 Autres : _____

Concernant le patient :

Sexe : M F
 Covid : Oui Non Suspicion Covid : Oui Non
 Température : ___ °C

ATCD : Maladie respiratoire chronique : Oui Non
 Autre atcd modifiant votre stratégie de ventilation : Oui Non Lequel : _____

Poids : ___ kg → Déclaré par le patient Estimé par l'urgentiste Autres* : _____
Taille : ___ cm → Déclaré par le patient Estimé par l'urgentiste Autres* : _____
 (* : carte d'identité / dossier médical / déclaré par les proches ...)

Paramètres ventilatoires : Mode de ventilation : VC/VAC PC/PAC autres : _____
 Degrés d'inclinaison de la tête du patient : 0° 30° 60° autres : _____

1^{ers} réglages ventilatoires :

Vt =	FR =
PEP =	FIO2=

Valeurs de surveillance :

SpO2 =	EtCO2 =
Pcrête =	

Réglages après ajustement, À l'admission au CHU :

Vt =	FR =
PEP =	FIO2=

Valeurs de surveillance :

SpO2 =	EtCO2 =
Pcrête =	

Concernant l'expérience du médecin avant initié la ventilation mécanique :

- Dr Junior
- Sénior depuis une durée de moins de 5 ans
- Sénior depuis une durée comprise entre 5 et 10 ans
- Sénior depuis une durée de plus de 10 ans

VENTILO APPLICATION

Ventilo
Implémentation et optimisation de la ventilation protectrice

Réglages ventilatoires COVID-19

PLUS sur les réglages initiaux au cours de la ventilation protectrice

Caractéristiques des Patients

Genre: Femme

Taille: 160 cm

Poids idéal théorique: PIT 52 kg

En savoir plus

Combinaisons proposées (V_T / RR)

mL/kg _{PBW}	V_T (mL)	FR (/min)
V_T 3	157	>35
V_T 4	210	>35
V_T 5	262	28 - 30
V_T 6	314	23 - 25
V_T 7	367	19 - 21
V_T 8	419	17 - 19
V_T 9	472	15 - 17
V_T 10	524	13 - 15

● Combinaisons principales ● Ventilation Ultraprotectrice

Réglages de V_T et FR

N'oubliez pas d'optimiser la ventilation (consulter la section **Optimisations de la ventilation**)

Réglages initiaux du ventilateur

Avertissement

Réglages initiaux du ventilateur

Poids réel: 60 kg

Température corporelle: 36.5 °C

Type de Patient: Soins intensifs

Indice de Masse Corporelle: IMC 23.4 Kg/m²

En savoir plus

Chartes des volumes courants en fonction de la taille et du sexe:

FEMME

TAILLE (cm)	PIT (kg)	V_T 4 mL/kg	V_T 5 mL/kg	V_T 6 mL/kg	V_T 7 mL/kg	V_T 8 mL/kg	V_T 9 mL/kg	V_T 10 mL/kg
145	39	155	194	233	271	310	349	388
147	41	162	203	244	284	325	365	406
149	43	170	212	254	297	338	382	424
151	44	177	221	265	310	354	398	442
153	46	184	230	276	322	368	414	460
155	48	191	239	287	335	383	431	479
157	50	199	248	298	348	397	447	497
159	52	206	258	309	361	412	464	515
161	53	213	267	320	373	427	480	533
163	55	221	276	331	386	441	496	551
165	57	228	285	342	399	456	513	570
167	59	235	294	353	412	470	529	588
169	61	242	303	364	424	485	545	606
171	62	250	312	375	437	499	562	624
173	64	257	321	385	450	514	578	642
175	66	264	330	396	462	529	595	661
177	68	272	339	407	475	543	611	679
179	70	279	349	418	488	558	627	697
181	72	286	358	429	501	572	644	715
183	73	293	367	440	513	587	660	733
185	75	301	376	451	526	601	678	752
187	77	308	385	462	539	616	693	770
189	79	315	394	473	552	630	709	788
191	81	323	403	484	564	645	726	806
193	82	330	412	495	577	660	742	824
195	84	337	421	506	590	674	758	843
197	86	344	430	517	603	689	775	861
199	88	352	440	527	615	703	791	879
201	90	359	449	538	628	718	808	897

HOMME

TAILLE (cm)	PIT (kg)	V_T 4 mL/kg	V_T 5 mL/kg	V_T 6 mL/kg	V_T 7 mL/kg	V_T 8 mL/kg	V_T 9 mL/kg	V_T 10 mL/kg
145	43	173	216	260	303	346	389	433
147	45	180	225	271	316	361	406	451
149	47	188	235	281	328	375	422	469
151	49	195	244	292	341	390	439	487
153	51	202	253	303	354	404	455	505
155	52	209	262	314	367	419	471	524
157	54	217	271	325	379	433	488	542
159	56	224	280	336	392	448	504	560
161	58	231	289	347	405	463	520	578
163	60	239	298	358	418	477	537	596
165	61	246	307	369	430	492	553	615
167	63	253	316	380	443	506	570	633
169	65	260	326	391	456	521	586	651
171	67	268	335	402	468	535	602	669
173	69	275	344	412	481	550	619	687
175	71	282	353	423	494	565	635	706
177	72	290	362	434	507	579	651	724
179	74	297	371	445	519	594	668	742
181	76	304	380	456	532	609	684	760
183	78	311	389	467	545	623	701	778
185	80	319	398	478	558	637	717	797
187	81	326	407	489	570	652	733	815
189	83	333	417	500	583	666	750	833
191	85	341	426	511	596	681	766	851
193	87	348	435	522	609	696	783	869
195	89	355	444	533	621	710	799	888
197	91	362	453	544	634	725	815	906
199	92	370	462	554	647	739	832	924
201	94	377	471	565	660	754	848	942

Le serment d'Hippocrate

Texte revu par l'Ordre des médecins en 2012

“ Au moment d'être admis(e) à exercer la médecine, je promets et je jure d'être fidèle aux lois de l'honneur et de la probité.

Mon premier souci sera de rétablir, de préserver ou de promouvoir la santé dans tous ses éléments, physiques et mentaux, individuels et sociaux.

Je respecterai toutes les personnes, leur autonomie et leur volonté, sans aucune discrimination selon leur état ou leurs convictions. J'interviendrai pour les protéger si elles sont affaiblies, vulnérables ou menacées dans leur intégrité ou leur dignité. Même sous la contrainte, je ne ferai pas usage de mes connaissances contre les lois de l'humanité.

J'informerai les patients des décisions envisagées, de leurs raisons et de leurs conséquences.

Je ne tromperai jamais leur confiance et n'exploiterai pas le pouvoir hérité des circonstances pour forcer les consciences.

Je donnerai mes soins à l'indigent et à quiconque me les demandera. Je ne me laisserai pas influencer par la soif du gain ou la recherche de la gloire.

Admis(e) dans l'intimité des personnes, je tairai les secrets qui me seront confiés. Reçu(e) à l'intérieur des maisons, je respecterai les secrets des foyers et ma conduite ne servira pas à corrompre les mœurs.

Je ferai tout pour soulager les souffrances. Je ne prolongerai pas abusivement les agonies. Je ne provoquerai jamais la mort délibérément.

Je préserverai l'indépendance nécessaire à l'accomplissement de ma mission. Je n'entreprendrai rien qui dépasse mes compétences. Je les entretiendrai et les perfectionnerai pour assurer au mieux les services qui me seront demandés.

J'apporterai mon aide à mes confrères ainsi qu'à leurs familles dans l'adversité. Que les hommes et mes confrères m'accordent leur estime si je suis fidèle à mes promesses ; que je sois déshonoré(e) et méprisé(e) si j'y manque.

”