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Effectiveness of anaesthesia ventilator use for mechanical ventilation in critically ill patients during the COVID-19 pandemic

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Editor—During the first 4 months of 2020, 5% of patients infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) required ICU admission and invasive mechanical ventilation (IMV)[1] overwhelming ICU capacities. To expand ICU capacity, French hospitals underwent substantial transformations,[2] limited by the lack of ventilation machines needed for supportive care.[3] The French Anaesthesia and Intensive Care Society (SFAR) stated that anaesthesia ventilators could be used for IMV in critically ill patients under well-defined conditions.[4] One of the most important settings is fresh gas flow, which has to be ≥150% of the patient's minute ventilation. The literature on this subject was virtually non-existent.

This was a retrospective, multicentre, observational cohort analysis with prospectively collected data to evaluate the effectiveness of IMV in ICU patients with anaesthesia ventilators in adherence with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[5] The primary objective was to evaluate the feasibility of use of anaesthesia ventilators for prolonged IMV in ICU patients, tracking ventilation failure within 72 h after IMV initiation, defined as any change in the type of ventilator used (except for logistic purposes). The secondary objective was to report specific management of these medical devices through condensation of water in the breathing circuit and ventilator as measured by the frequency of filter changes and water trap emptying.

Study design was described in a preliminary report.[6] Ethics committee approval was obtained by the French Pneumology Society (CEPRO 2020-017). All adult patients admitted to one of the five Parisian university hospital study centres who required IMV for more than 24 h, regardless of whether they had COVID-19, were included if an anaesthesia ventilator was used at the beginning of IMV because of a shortage of ICU ventilators. Data collection and handling are described in the Supplementary data. Data included patient characteristics, COVID-19 status, medical information, ventilation characteristics, ICU-specific care, outcome, and arterial blood gas analysis at 72 h after ICU admission. A descriptive analysis was performed using R® software (https://www.r-project.org/; medians and inter-quartile ranges, frequencies and percentages when applicable, with calculation of 95% confidence intervals).

From March 21 to April 13, 2020, 50 patients were enrolled (Table 1 and Supplementary Table S1). 41 patients (82%) had COVID-19 at baseline and 47 patients (94%) were admitted to ICU for respiratory distress. Every patient was managed using ventilation control mode (Supplementary Table S2). Six patients required a switch from an anaesthesia ventilator to an ICU ventilator within the first 72 h of IMV. Three patients were transferred to another French region in which the pandemic was less widespread. One was transferred to a regular ICU when a bed became available (four switches considered 'logistical'). The last two patients required a ventilator switch because of ventilation failure, defined as hypercapnia or high plateau pressure that could not be resolved by adjusting the ventilator settings. The change in ventilator helped bring hypercapnia under control in one patient; however, it did not reduce the high plateau pressure in the second patient, who was switched to extracorporeal membrane oxygenation within a few hours. Filters were changed every 1 [1–1.5] day, and water traps were emptied every 3.6 [2.5–6.8] days. Twelve

Table 1 Patient characteristics, intensive care and outcome (n=50). *There is one missing value for the variable. †Thirteen values are missing for two centres. COPD, chronic obstructive pulmonary disease; ECMO, extracorporeal membrane oxygenation; GCS, Glasgow Coma Scale; IQR, inter-quartile range.

Patient characteristics	Total cohort (n=50)
Age (yr), median [IQR]	61 [51–68]
Sex male, n (%)	34 (68)
Comorbidities	
Arterial hypertension, n (%)	29 (58)
History of cardiovascular diseases, n (%)	7 (14)
COPD,* n (%)	5 (10)
Obesity, n (%)	22 (44)
Diabetes mellitus (types 1 and 2), n (%)	15 (30)
Documented case of COVID-19, n (%)	41 (82)
ICU cause of admission	
Hypoxaemic pneumonia	46 (92)
Coma (GCS <8)	2 (4)
Septic shock	1 (2)
Haemoptysis	1 (2)
SOFA score at ICU admission,* median [IQR]	12 [10–13]
ICU therapeutic management during the first 72 h	
Tracheal tube diameter, mm	
7.0, n (%)	6 (12)
7.5, n (%)	33 (66)
8.0, n (%)	11 (22)
Prone positioning,* n (%)	30 (61)
ECMO,† n (%)	3 (8)
Renal replacement therapy,† n (%)	4 (11)
Reasons for switching before 72 h	
Ventilator switch during the first 72 h, n (%)	6 (12)
Hypercapnia, n (%)	1 (17),
High plateau pressure, n (%)	1 (17)
Logistical reason or patient relocation, n (%)	4 (66)
Outcome	
Hospital length of stay (days), median [IQR]	26 [15–41.5]
Duration of invasive ventilation (days), median [IQR]	13.5 [7–22]
ICU length of stay (days), median [IQR]	16 [11–28]

patients (24%) died within 28 days of ICU admission (Supplementary Table S3).

The updated guidelines from the Surviving Sepsis Campaign on IMV recommendations for COVID-19 patients[7] did not take into consideration limitations of existing ICU infrastructure. Several strategies have been reported during the pandemic to address the lack of ICU ventilators[8]: construction of new machines in a timely efficient manner, ventilation of several patients with one machine (all scientific societies strongly advised not to adopt this strategy[9]) or use of anaesthesia ventilators (see Supplementary data for historical design of anaesthesia ventilators).

Thanks to a six-fold decrease in surgeries, equipment (anaesthesia ventilators) and staff (nurses and anaesthesiologists, with dual ability in anaesthesiology and intensive care) were reallocated to regular and temporary ICUs, allowing coverage by trained physicians with intensive care experience.[10] Care was provided with the same protocols and the highest possible quality, regardless of which type of unit the patients were hospitalised in. In clinical practice, the recommendation is to change heat and moisture exchanger (HME) filters after every anaesthesia procedure,[11] although their efficacy has been the subject of controversy, especially in condensation and high-pressure conditions. For pneumonia prevention in mechanically ventilated ICU patients, the recommendation is to change the HME when it mechanically malfunctions or becomes visibly soiled. We assumed that the same strategy should be used during prolonged IMV with an anaesthesia ventilator.

Our study has several limitations, such as potential bias induced by the definition of logistical reasons for changes in ventilators and the retrospective aspects (which prevented us from collecting additional data such as lung compliance). Moreover, the 72 h duration may not be sufficient to evaluate the safety and effectiveness of this strategy; that time frame was selected as a compromise between study feasibility and evaluation quality. We were not able to assess the impact of anaesthesia ventilator use on outcomes or gas exchange, as this was not the purpose of our study. Recently, a large ICU study performed during the same time frame reported comparable IMV duration and hospital/ICU length of stay.[12] Acute respiratory distress syndrome (ARDS) in COVID-19 patients displays distinctive features (see Supplementary data), different from conventional ARDS,[13] although this is subject to controversy. Thus, an anaesthesia ventilator may not represent an acceptable temporary solution for patients with severe ARDS and low compliance. Finally, most patients were ventilated with Draëger anaesthesia ventilators, which should be taken into consideration for further studies.

This study is the first to report clinical data pertaining to IMV in critically ill patients with anaesthesia ventilators. One of the most important settings is the fresh gas flow, which has to be ≥150% of minute ventilation. Prolonged IMV with anaesthesia ventilators should be considered to facilitate the provision of additional ICU beds during pandemics to meet the needs of patients with respiratory distress, provided there is strict adherence to published recommendations to ensure safety and efficacy.

Declarations of interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2021.04.001.

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Biological, psychological, and social factors associated with worsening of chronic pain during the first wave of the COVID-19 pandemic: a cross-sectional survey

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Editor—Recent reviews have identified several specific problems of people with chronic pain arising during the COVID-19 pandemic.[1,2] Likewise, the importance of examining particular vulnerable groups has also been pointed out.[3,4] We aimed to identify biological, psychological, and social factors that correlate with the worsening of chronic pain during the first COVID-19-related lockdown.

This cross-sectional study was approved by the Ethics Committee of the Medical University of Graz, Austria (Number: 32–488 ex 19/20). From July 1 to July 15, 2020, an open, web-based survey was conducted using SoSci Survey software (SoSci Survey GmbH, Munich, Germany). Adults with chronic pain for at least 1 yr were recruited through self-help groups in Germany, Austria, and Switzerland.

The survey was developed in a stepwise process: formation of interdisciplinary team (three anaesthesiologists and pain physicians, one neurologist, two general practitioners, two pain nurses, one psychologist, one physiotherapist), individual identification of topics to be included in the questionnaire, and prioritisation and selection of the items to be included in the questionnaire by voting of the team. To validate the questionnaire, the intraclass correlation in a sample of 10 people with chronic pain who answered the survey twice in 24 h was assessed as 0.87.

The survey is presented as Supplement file 1, with an English translation in Supplement file 2. It included questions on sociodemographic data, pain intensity (VAS 0–100) before and during the COVID-19 lockdown, pain-related variables, pharmacological and non-pharmacological pain management, physical activity, psychological factors (including the Pain Catastrophizing Scale [PCS], Resilience Scale [RS-13], and a short version of the Big Five Inventory [BFI-10]), social factors, and the availability of and satisfaction with healthcare. As there was no uniformity regarding the date on which the social restrictions came into effect in different regions, we used general expressions in the questionnaire such as ‘the weeks before COVID-19’ or ‘COVID-19 phase’.

To establish the predictive model of the dependent variables, and the difference between the average pain sensation before and after the COVID-19 lockdown, respectively,