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From Rapid Manufacturing to Clinical Use: A Retrospective Observational Study of an Emergency Ventilator During the COVID-19 Pandemic

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Original Research

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Abstract

Objective: The COVID-19 pandemic spurred efforts to develop emergency ventilators, though few progressed beyond laboratory testing. This study evaluates CoroVent, a rapidly manufactured ventilator, during real-life deployment in critically ill COVID-19 patients amid ventilator shortages.

Methods: This retrospective observational study included patients ventilated with emergency ventilator CoroVent. This device uses a novel and unique way of generating inspiratory flow and gas mixing using fast ON/OFF valves for air and oxygen, producing pneumatic pulses that are then smoothed into continuous flow. Clinical data were collected from 3 hospitals between October 2020 and March 2021, selected from 27 contacted, of which 23 responded and 4 reported clinical use.

Results: Eight male patients (mean age 67 years, BMI 37.2 $kg{\cdot}m^{-2}$) with COVID-19 or suspected infection were ventilated with CoroVent for 31.3 (10.0–58.5) hours. The mean FiO_2 was 71.4%, PEEP 10.6 cmH_2O, and Vt 8.9 $mL{\cdot}kg^{-1}$ predicted body weight. CoroVent was used as an initial or replacement ventilator during device shortages. No major technical failures occurred.

Conclusions: This is the first report of real-life clinical use of a rapidly manufactured emergency ventilator during the COVID-19 pandemic. The results confirm that such devices, if well-designed, can provide effective respiratory support when conventional ventilators are unavailable.

Introduction

The onset of the COVID-19 pandemic in spring 2020 raised concerns about potential shortages of mechanical lung ventilators in certain regions. Initial reports, particularly from Italy, highlighted this issue,[1–2] prompting global efforts to design rapidly manufacturable ventilators using widely available components.[3] However, most of these ventilator concepts relied on mechanically operated manual resuscitation bags[4] and did not meet the requirements for critical care ventilation.

To address this challenge, we developed a novel approach to inspiratory flow generation and gas mixing, specifically designed to enable the rapid production of ventilators suitable for critical care settings in pandemics or other mass-casualty incidents.[5] This principle was implemented in the CoroVent ventilator, which was manufactured in the Czech Republic. Unlike conventional critical care ventilators, CoroVent was built using readily available industrial components, allowing for large-scale production even during supply chain disruptions.[6] The ventilator received emergency use authorization from the Czech Ministry of Health and the U.S. Food and Drug Administration (FDA)[7] and was distributed free of charge to Czech hospitals.

CoroVent was first used clinically on October 31, 2020, in a critically ill patient, with its performance evaluated using an independent monitoring system during a planned 24-hour ventilation period, in which no adverse effects were observed and all monitored parameters remained within the limits defined by international standards (ISO 80601-2-12).[8] Since then, additional patients have been ventilated using CoroVent in various clinical settings.

This study aimed to evaluate the clinical performance of CoroVent in real-life clinical use during the COVID-19 pandemic (October 2020–April 2021). Additionally, it sought to identify any technical or clinical complications associated with its use.

Methods

The retrospective observational study has been approved by the Institutional Ethical and Review Board of the Faculty of Biomedical Engineering, Czech Technical University in Prague

(No. B4/2021, issued on May 4, 2021). This study was conducted in accordance with the STROBE guidelines to ensure transparent and comprehensive reporting of observational data.[9]

Study Protocol

Ventilator CoroVent was distributed to 27 Czech hospitals between October 2020 and April 2021. During May 2021, contact persons from all 27 hospitals were approached regarding the clinical use of the ventilator CoroVent in their patients. Clinicians from hospitals that reported clinical use of the ventilator were asked to fill in a study protocol (in Suppl. material) for each patient and ventilator use. The study protocol included basic demographic data of each patient, the type of airway management, and questions on the circumstances of the connection and disconnection of the ventilator CoroVent. Clinicians from these wards were also interviewed about their experience with CoroVent.

A series of arterial blood gas analyses (ABG) was included in the protocol: measurements before and after connection, disconnection from the ventilator, and following changes in ventilation parameters. Ventilation parameters were recorded manually into the protocol from the ventilator screen and pressure gauge, namely tidal volume (Vt), respiratory rate (RR), inspired fraction of oxygen (FiO_2), inspiratory to expiratory (I:E) time ratio, and positive end-expiratory pressure (PEEP). There was no independent monitoring of ventilatory parameters available. Other parameters, peripheral oxygen saturation (SpO_2) and end-tidal carbon dioxide ($ETCO_2$), were recorded manually from the patient's standard vital sign monitor screen.

All patients ventilated using CoroVent between October 31, 2020, and April 30, 2021, were eligible for the study. All data extracted from the hospital records were fully anonymized; no data on patient identifiers were available, and the need for formal patient consent was waived. The clinicians involved in patient care collected physiological and demographic data and subsequently recorded them anonymously. The study protocol did not include any follow-up, and we did not evaluate patient outcomes beyond the ventilation period.

Equipment

Patients included in the study were ventilated using the rapidly developed emergency ventilator CoroVent (MICo Medical Ltd., Trebic, Czech Republic). The principle of this ventilator was designed by a team of biomedical engineers and critical care physicians at the Faculty of Biomedical Engineering, Czech Technical University in Prague, in response to the clinical situation during the early phase of the COVID-19 pandemic in March 2020, in collaboration with mechanical and electrical engineers and programmers.[5,10]

The inspiratory flow generation in ventilator CoroVent is assured by 2 fast computer-controlled ON/OFF valves, one for air and one for oxygen, as depicted in Fig. 1. A series of short pneumatic pulses, generated by the fast opening and closing of the ON/OFF valves, is then smoothed by pneumatic pulse filters to produce the desired constant inspiratory flow. Air and oxygen are then evenly mixed in the mixing chamber. Cycling between the inspiratory and expiratory phases is assured by a pneumatically controlled expiratory valve (CoroExsp), which functions as a pressure-relief valve limiting the maximum inspiratory pressure during inspiration and as a regulator of PEEP during expiration.

Both ON/OFF valves use pulse width modulation to generate the desired inspiratory flow magnitude, shape, and tidal volume while controlling the oxygen fraction in the ventilation mixture. With proper timing of both the ON/OFF valves and the expiratory valve (Fig. 2), the valves also control the respiratory rate and the inspiratory to expiratory time ratio and generate the inspiratory plateau. As a result, CoroVent provides only a volume-controlled pressure-limited mode of ventilation and does not allow any triggering.

The ventilator uses a standard circuit with a 2-way patient circuit, heat and moisture exchanger (HME), and a specially designed flow and pressure sensor—CoroQuant (Fig. 3), which works as a pneumotachograph.[12] The sensor is a 12 cm long tube terminated on both sides with a 2 cm long conical connector allowing connection to standard components of the patient's ventilation circuit. The CoroQuant is capable of monitoring the bidirectional flow of the ventilation mixture over a range of flow rates from 0 to 80 L $\cdot min^{-1}$.

Prior to its distribution to health care facilities, the CoroVent ventilator underwent preclinical testing, the results of which are described with more detailed technical description of the ventilator in separate publications.[5,10] The testing protocol was consistent with the framework proposed by Barglyas *et al.* for the mandatory ventilation.[13]

Data Analysis

All data analyzed in this study were retrospectively extracted from patient medical records, based on values manually transcribed during clinical care from the CoroVent ventilator screen, bedside monitors, and point-of-care ABG printouts.

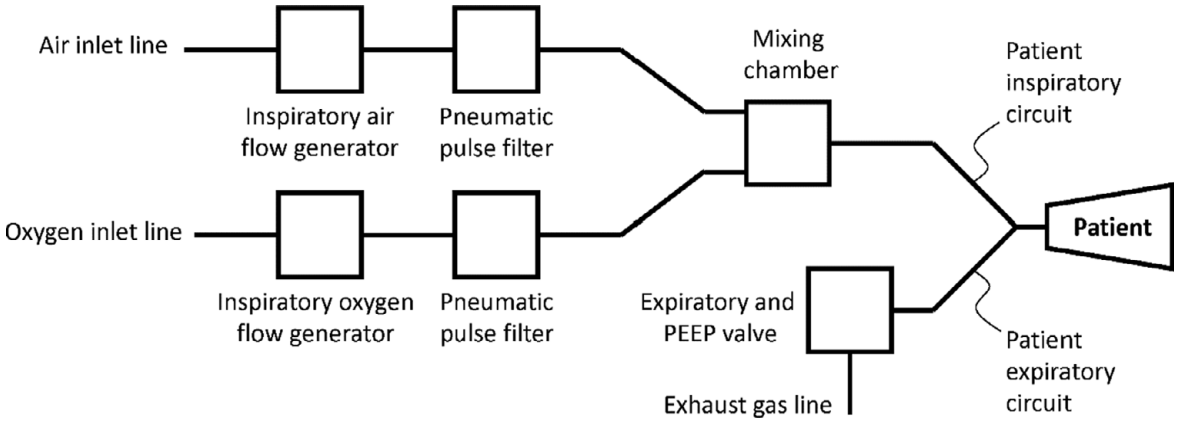

Figure 1. The structure and essential functional parts of a novel operating principle of inspiratory flow generation and gas mixing in CoroVent ventilator. Modified from the patent documentation.[11]

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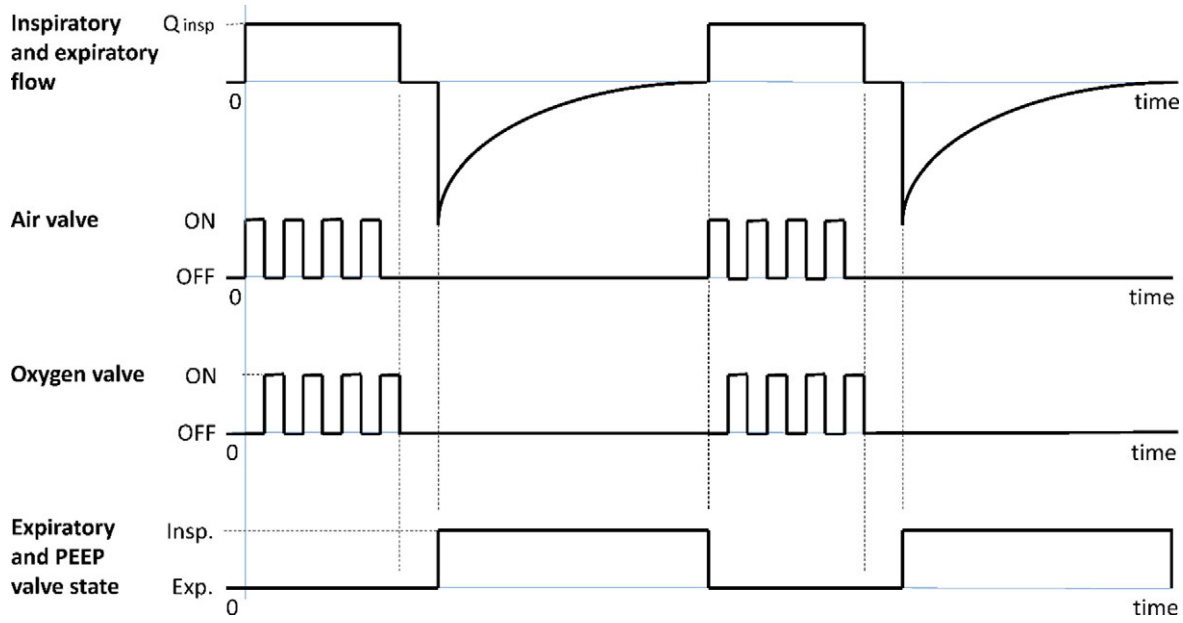

Figure 2. The gas flow profile in the airways generated by the CoroVent ventilator (top graph) and control signals of three valves: ON-OFF air valve, ON-OFF oxygen valve, and the 3-way expiratory valve.

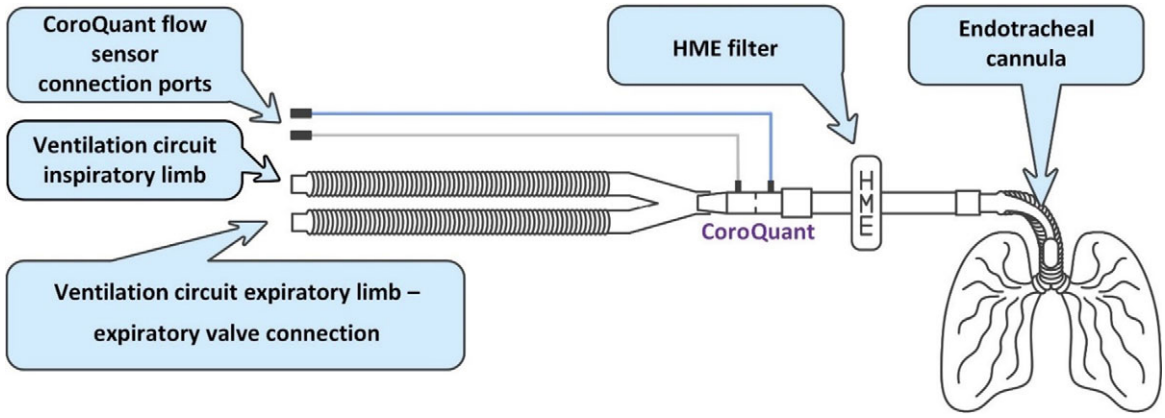

Figure 3. Diagram of the CoroVent ventilation circuit, including its typical setup with the CoroQuant flow sensor.

The demographic data obtained from the patients and the set ventilation parameters were processed as means (minimum–maximum values). Time trends were monitored for the collected clinical parameters. Missing data were addressed using a complete case analysis approach; no imputation methods were utilized. The number of missing data points was reported in the Results section. All data were analyzed anonymously.

Results

In May 2021, 27 Czech hospitals were contacted regarding the clinical use of the CoroVent ventilator and potential study participation. Of these, 23 hospitals responded, and clinical use was reported in 4 hospitals. However, only 3 hospitals agreed to participate in the study (Fig. 4). The participating centers included a large teaching hospital, a small hospital in Prague, and a district hospital.

Between October 31, 2020, and March 8, 2021, 8 male patients were reported to be ventilated with CoroVent. The basic information about the patients included in the study is in Table 1.

All patients were ventilated due to the infection of COVID-19, except for one who was in respiratory failure with profound hypercapnia and in whom the presence of SARS-CoV-2 virus had not been confirmed. Half of the patients were connected to CoroVent following ventilation with a standard ventilator for critical care. Two patients were switched from a transport ventilator (1 directly from an ambulance ventilator). In 2 other patients, CoroVent was the first ventilator they were put on following the intubation. Only 1 patient was ventilated through a tracheostomy; the rest had an endotracheal tube in situ.

All patients were sedated during the ventilation, and muscle relaxation was used in 6 patients, but only 1 patient required the relaxation due to interference with CoroVent; for the rest of them, there was a clinical indication for the administration of muscle relaxants. Patients were ventilated only in supine position.

The average set ventilatory parameters in all patients in the studied group are in Table 2, including the range of individual parameters available in CoroVent.

An example of ABG analysis results and set ventilatory parameters of one of the COVID-19 patients is presented in Table 3.

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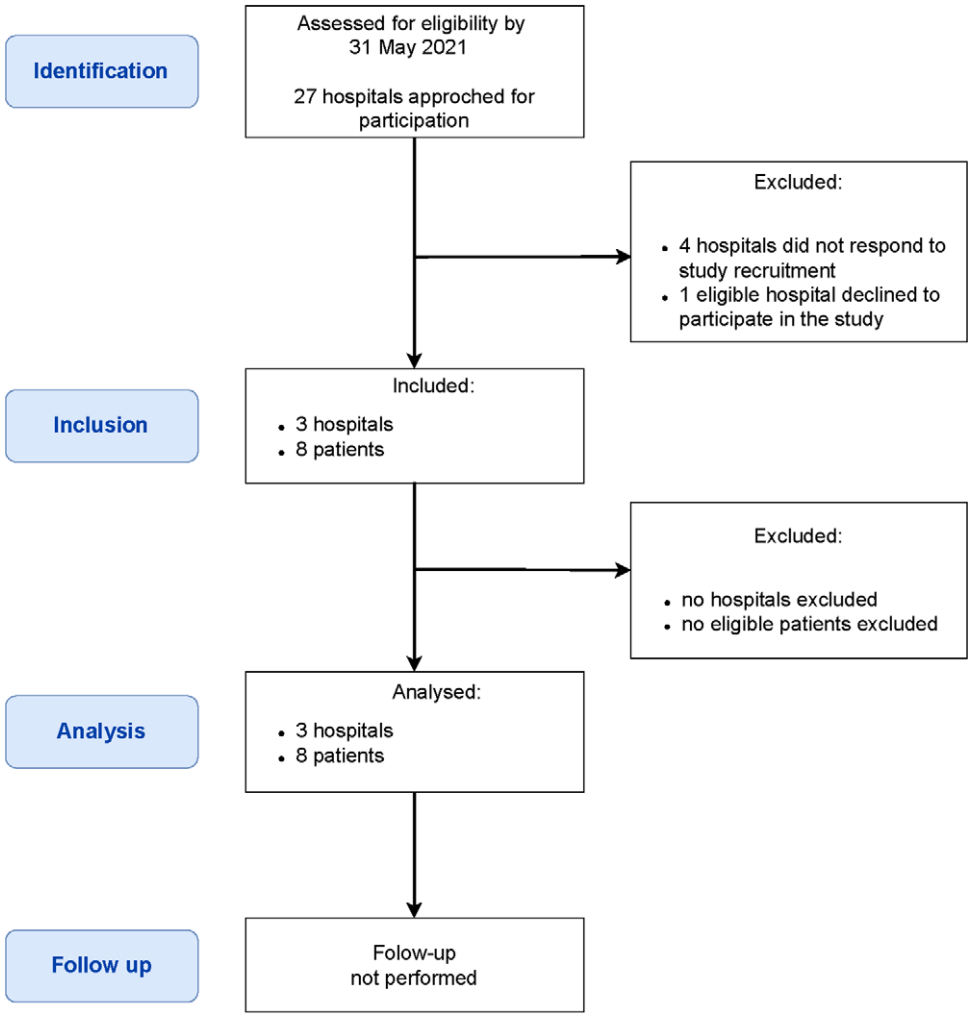

Figure 4. Flow diagram of the study.

Table 1. Basic information about the patients ventilated by CoroVent (n = 8)

Parameter	Mean (min–max)
Age (years)	66 (35–79)
Weight (kg)	113 (70–152)
Height (cm)	174 (168–180)
BMI ($kg \cdot m^{-2}$)	37.2 (24.2–50.2)
Duration of ventilation (hours)	31.3 (10.0–58.5)
Horowitz index PaO_2/FiO_2 (mmHg)	109.4 (75.0–204.9)
Vt ($mL \cdot kg^{-1}$ PBW)*	8.9 (6.8–12.9)

*For tidal volumes, the predicted body weight (PBW) was calculated according to the ARDS net formula.[14]

Table 2. Set values of ventilation parameters in the presented patient cohort, and the range available in CoroVent ventilator

Parameter	Mean (min–max) in patient cohort	CoroVent range of the parameter
Vt (mL)	603 (419–900)	200–800 (min guaranteed range)
RR (min^{-1})	18.5 (15–29)	5–45
FiO_2 (%)	71.4 (45–90)	21–100
I:E	1:1–1:2	1:1–1:4
PEEP (cmH_2O)	10.6 (9–13)	0–30

This 71-year-old patient was connected to CoroVent straight from an ambulance transport ventilator with FiO_2 100% in a situation of ventilator scarcity in the receiving ICU. In total, he spent more than 58 hours on CoroVent. The ABG showed an improving Horowitz index and a good response to respiratory acidosis, occurring 15 hours postconnection. With an increased minute ventilation, a stabilization of pH and $PaCO_2$ values was observed in ABG results obtained 26 hours postconnection. This patient was subsequently connected to a standard ventilator to initiate weaning from mechanical ventilation.

An example of ventilatory parameters and ABG results of a 65-year-old patient with BMI 42 $kg \cdot m^{-2}$ (actual body weight 135 kg) who was ventilated due to hypercapnic respiratory failure is in Table 4. This patient had a clinical presentation consistent with COVID-19, but the diagnosis was not laboratory confirmed. The presented parameters showed improvement in oxygenation and CO_2 elimination in conjunction with improvement of the Horowitz

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Table 3. Example of ventilatory parameters and arterial blood gas analysis in a COVID-19 patient before, during, and after disconnection from the ventilator CoroVent

Time	Vt	RR	FiO_2	PEEP	pH	$PaCO_2$	PaO_2	HCO_3^-	PaO_2/FiO_2
13 min before connection	NA	NA	100	NA	7.33	5.7	10.2	22.3	76
2 hr post connection	480	16	80	12	7.34	5.3	11.6	21.7	109
15 hr post connection	480	18	60	12	7.27	7.5	10.0	21.8	125
26 hr post connection (20 hr before disconnection)	480	20	60	10	7.44	6.2	10.1	29.2	126
1 hr post disconnection	NA	NA	55	10	7.44	7.0	11.7	32.0	159

FiO_2, Inspired fraction of oxygen in %; HCO_3^-, standard bicarbonate in $mmol/L^{-1}$; NA, value not available; $PaCO_2$, arterial partial pressure of CO_2 in kPa; PaO_2, arterial partial pressure of O_2 in kPa; PaO_2/FiO_2, Horowitz index in mmHg; PEEP, positive end-expiratory pressure in cmH_2O; RR, respiratory rate in min^{-1}; Vt, tidal volume in mL.

Table 4. Example of ventilatory parameters and arterial blood gas analysis in a non-COVID-19 patient with acute respiratory failure before, during, and after disconnection from the ventilator CoroVent.

Time	Vt	RR	FiO_2	PEEP	SpO_2	$ETCO_2$	pH	$PaCO_2$	PaO_2	HCO_3^-	PaO_2/FiO_2
before connection	NA	NA	70	10	86	NA	7.17	15.7	8.8	42.3	94
2 hr post connection	750	16	70	10	88	8.0	7.39	8.0	7.1	35.5	76
4 hr post connection	850	16	70	10	97	6.2	7.50	5.8	12.1	33.1	130
18 hr post connection	800	16	60	10	98	5.8	7.55	5.5	11.6	35.7	145
32 hr post connection (5 hr before disconnection)	800	16	60	10	97	5.3	7.53	5.0	9.4	30.4	117
1 hr post disconnection	800	16	60	10	96	5.1	7.49	4.8	10.2	26.9	128

FiO_2, inspired fraction of oxygen in %; HCO_3^-, standard bicarbonate in $mmol/L^{-1}$; NA, value not available; $PaCO_2$, arterial partial pressure of CO_2 in kPa; PaO_2, arterial partial pressure of O_2 in kPa; PaO_2/FiO_2, Horowitz index in mmHg; PEEP, positive end-expiratory pressure in cmH_2O; RR, respiratory rate in min^{-1}; Vt, tidal volume in mL.

index from 94 mmHg to 145 mmHg during the first 18 hours post connection to the CoroVent ventilator.

Three patients died on CoroVent, but in all cases, the death was expected due to bad prognosis; the attending clinicians did not associate the death with the use of CoroVent and there was no cardiopulmonary resuscitation performed during the study period in any of the ventilated patients. Majority of the patients were subsequently connected to a standard critical care ventilator, in 3 cases with the aim to start the weaning from mechanical ventilation. In one case, the indication for disconnection from CoroVent was to switch to another type of ventilation mode. The patient with a tracheostomy suffered from its dislocation during positioning while on CoroVent and following securing of his airways, the attending clinician decided to put him on a conventional ventilator.

Regarding technical issues, no major malfunctions were reported by clinicians. However, 1 case of unstable PEEP was observed, where a set PEEP of 12 cmH_2O intermittently dropped to approximately 5 cmH_2O without an apparent cause.

In terms of user experience, nursing staff at one hospital reported concerns about the loudness of the ventilator alarms. Additionally, medical staff from 2 hospitals found the ventilator operation more complicated compared to standard critical care ventilators, whereas staff at the third hospital considered its use intuitive and encountered no major difficulties.

Some missing data were observed in all 8 patients. Ventilation setting data had 18.7% missing values, while ABG data had 21.0% missing values. For other parameters, the proportion of missing data was high (45.2%), mainly due to poor reporting of $ETCO_2$, with 18 out of 31 values missing.

Discussion

This study demonstrates that a rapidly developed ventilator that is simple in design, easy to manufacture, and obeys principal requirements for accuracy and safety, defined by the international standards for critical care mechanical lung ventilators (ISO 80601-2-12), can provide ventilation in a pandemic situation.

To our knowledge, this is the first clinical study reporting the use of a rapidly developed ventilator during the COVID-19 pandemic in critically ill patients requiring invasive ventilation in real clinical scenarios. Unlike other emergency ventilators, which were primarily evaluated in laboratory settings[15-17] or tested in animal models,[18-20] CoroVent was used for full clinical support in patients with acute respiratory failure due to COVID-19. While one recently published study[13] described 1-hour testing of an emergency ventilator in critically ill patients with a variety of diagnoses—including a single COVID-19 case—our study represents the first documentation of routine clinical use of such a device for full respiratory support in patients with pandemic-related acute respiratory failure.

Although our study includes only 8 patients, most of them personified a typical ICU patient hospitalized for severe respiratory failure due to COVID-19 during the first pandemic waves.[21] Three of our patients had a BMI >40 $kg{\cdot}m^{-2}$ (one of them 50.2 $kg{\cdot}m^{-2}$), and two others had moderate obesity with a BMI >30 $kg{\cdot}m^{-2}$; BMI was not reported in one patient. It has been proven at the beginning of the pandemic that obesity, and especially severe obesity, is associated with an increased risk of serious disease requiring admission to ICU, mechanical ventilation, and increased mortality.[22-23]

The presented patient group and their ventilatory parameters (Table 2) demonstrate that although not the whole range of settings were tested in the clinical environment, the set parameters are in

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agreement with worldwide experience. In the meta-analysis reporting patients ventilated due to COVID-19 by Grasseli *et al.*,[24] volume-controlled ventilation was used in 4 out of 5 studies that reported the mode. The respiratory rate set on CoroVent 15–29 breaths per minute (min–max) is only slightly lower than the reported 20–33 breaths per minute, and a similar situation was for PEEP reaching 9–13 cmH_2O on CoroVent and 9.0–16.5 cmH_2O in the cited meta-analysis. A different situation was observed for tidal volume, which in other studies is kept within protective limits of 5.6–7.5 $mL{\cdot}kg^{-1}$ PBW, but in our patient cohort, the value was higher, at 6.8–12.9 $mL{\cdot}kg^{-1}$ PBW, with a mean value of 8.9 $mL{\cdot}kg^{-1}$ PBW. No reason for this setting was charted in any of the study protocols. In one patient, Vt was set to 900 mL, which exceeded the minimum guaranteed value. For the CoroVent, the minimum guaranteed range of Vt has been set at 800 mL; however, with an appropriate combination with the I:E, it is possible to set an even higher Vt, as the Vt range is not limited by software, but based on the setting of individual ventilation parameters. Nevertheless, the volume was probably too high, with a tidal volume of 12.9 $mL{\cdot}kg^{-1}$ PBW. Unfortunately, no data on plateau or driving pressures are available.

Patients were ventilated only using pressure-limited volume-controlled ventilation, the only mode available in CoroVent, and for weaning from ventilatory support, they had to be switched to a different ventilator for critical care (and that was the case in 3 patients, including the patient whose parameters are presented in Table 3). On the other hand, this ventilator is intended to provide bridging therapy in case of scarcity of standard lung ventilators. In the future, if needed, the hardware will allow the upgrading of the software for triggered modes.[5]

The clinical experience did not reveal any major technical problems when operating the ventilator. Most staff found its use intuitive following standard training. The main challenge was adjusting PEEP, as it was set using a rotary knob, with the selected value displayed on the screen after a 1-breath delay.[10] The only reported technical issue was one case of unstable PEEP, the cause of which remained unclear despite review of the protocol and discussions with attending clinicians. Additionally, nursing staff in one instance found the alarm sound too loud, though its volume complied with the international standard (ISO 60601-1-8). Despite its technical simplicity and intuitive interface, CoroVent was intended for use by physicians with appropriate qualifications in critical care, as safe ventilation management requires professional expertise beyond operating the device itself.

Despite this isolated PEEP instability, the ventilator demonstrated stability in other key ventilatory parameters. This is further supported by findings from the first clinical use of CoroVent, where an independent monitoring system confirmed that minute ventilation, PEEP, peak airway pressure, and FiO_2 remained within the limits defined by international standards for critical care ventilators (ISO 80601-2-12).[8] These results reinforce the accuracy and reliability of CoroVent's ventilatory performance, further supporting its potential as an emergency alternative to conventional ventilators.

Among the patients included in this study, 3 did not survive. However, none of these deaths was attributed to the ventilator itself. According to the attending clinicians, all 3 patients had a poor prognosis at the time of admission. In one case, CoroVent was used for palliative ventilation at a small district hospital due to the acute unavailability of conventional ventilators in an overwhelmed facility. In another hospital, 3 patients were ventilated with CoroVent within 24 hours, and one of them, a 79-year-old patient, died after 15 hours of palliative ventilation. This case exemplifies the intended role of "emergency ventilators"—to provide ventilatory support when the demand exceeds the availability of standard devices.[2] This also corresponds to the fact that, with the exception of its first clinical use, CoroVent was employed in all cases due to the temporary unavailability of standard critical care ventilators during local shortages.

The CoroVent ventilator employs a novel approach to generating inspiratory flow,[11] resulting in distinct flow and pressure characteristics. While its performance has been extensively evaluated in laboratory settings,[5,10] this study provides the first real-world clinical data supporting its feasibility in patient care. The findings suggest that this approach may hold potential for broader applications in respiratory support, particularly in crisis scenarios.

This study has several limitations. Firstly, only 8 male patients with a mean age of 66 years were connected to CoroVent; no female patient was presented in the cohort. Due to the nature of the study and the pandemic situation, this was not influenceable. On the other hand, men over 60 formed the majority of patients hospitalized in ICU for COVID-19 in the early phase of the pandemic.[21] Moreover, the age range of 35–79 for presented patients is quite broad.

Secondly, most patients were ventilated due to COVID-19, and no other diagnoses (chronic obstructive disease, etc.) were tested. On the other hand, the ventilator was designed for the COVID-19 pandemic and approved for this unique situation by the national and international authorities. On the contrary, the Horowitz index of the patient group ranged from mild to severe ARDS with an average value within moderate hypoxemia (PaO_2/FiO_2 = 109.4 mmHg),[25] so there was some diversity in the study group. In Table 4, the ventilatory and ABG parameters of the only patient who did not have a laboratory-confirmed diagnosis of COVID-19 are presented. In this case, as well, the improvement in respiratory failure can be observed (similar to the example from a COVID-19 patient in Table 3).

The successful ventilation of 8 critically ill patients with CoroVent demonstrates its ability to provide adequate respiratory support in a clinical setting. Notably, CoroVent appears to be the only rapidly developed ventilator used in actual patients during the COVID-19 pandemic. Although the sample size is limited, these findings suggest that CoroVent could be a viable emergency alternative to conventional ventilators, particularly in mass-casualty situations that require rapid ventilator deployment.

Beyond its clinical performance, CoroVent exemplifies how crises can drive technological innovation. Designed with widely available industrial components, it enables large-scale production even when conventional ventilator supply chains are disrupted. However, while ventilator shortages were a major concern during the pandemic,[2,26] the primary limiting factor in critical care was ultimately the availability of trained health care personnel.[3,26] Looking ahead, advancements in artificial intelligence and automation may help mitigate such workforce constraints in future health crises, further shaping the role of emergency ventilators like CoroVent in disaster preparedness.

Conclusions

The real-life clinical use of the emergency CoroVent ventilator demonstrated that, when principal requirements are properly addressed, it is possible to rapidly design and manufacture a ventilator capable of effective patient ventilation, as evidenced by its successful deployment during the COVID-19 pandemic (October 2020–April 2021) to help address ventilator shortages. Its timely

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distribution ensured delivery to hospitals during a critical period of need.

The CoroVent's controls were comparable to those of conventional critical care ventilators. PEEP was the most challenging parameter to adjust, though still manageable. Gradual reductions in FiO_2 and other parameters were achievable, and patients were transitioned to different ventilators for weaning, in line with the initial design plan.

Supplementary material. The supplementary material for this article can be found at http://doi.org/10.1017/dmp.2025.10194.

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Author contribution. All authors contributed to study design. L.H., S.W., and K.R. performed the data analysis. All authors evaluated the measured data. K.R. created or modified all figures. All authors contributed to the manuscript writing and all authors reviewed and approved the final manuscript.

Competing interests. All authors (Lenka Horakova, Vaclav Ort, Ladislav Bis, Simon Walzel, and Karel Roubik) declare competing interests. The emergency lung ventilator CoroVent, described and clinically tested in this study, was manufactured by MICo Medical, Ltd. during the COVID-19 pandemic (April 2020–March 2021), funded by a public donation campaign in the Czech Republic, and distributed free of charge to Czech hospitals. Since March 2021, CoroVent has been out of production and is no longer commercially available. All authors contributed to the development and testing of the prototype ventilator unit; however, the final version distributed to hospitals was developed by a broader team of engineers and experts.

The principle of the inspiratory flow generation and gas mixing suitable for critical care ventilators was patented by K.R. and V.O., Czech patent No. 309 212, published on May 25, 2022.

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