

Mechanical ventilator as a shared resource for the COVID-19 pandemic

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Abstract

COVID-19, the causative agent of which is a new type of coronavirus called SARS-CoV-2, has caused the most severe pandemic in the last 100 years. The condition is mainly respiratory, and up to 5 % of patients develop critical illness, a situation that has put enormous pressure on the health systems of affected countries. A high demand for care has mainly been observed in intensive care units and critical care resources, which is why the need to redistribute resources in critical medicine emerged, with an emphasis on distributive justice, which establishes the provision of care to the largest number of people and saving the largest number of lives. One principle lies in allocating resources to patients with higher life expectancy. Mechanical ventilator has been assumed to be an indivisible asset; however, simultaneous mechanical ventilation to more than one patient with COVID-19 is technically possible. Ventilator sharing is not without risks, but the principles of beneficence, non-maleficence and justice prevail. According to distributive justice, being a divisible resource, mechanical ventilator can be shared; however, we should ask ourselves if this action is ethically correct.

KEY WORDS: COVID-19. Pandemic. SARS-CoV-2. Mechanical ventilator. Bioethics.

El ventilador mecánico como recurso divisible ante la pandemia de COVID-19

Resumen

COVID-19, cuyo agente causal es un nuevo tipo de coronavirus denominado SARS-CoV-2, ha provocado la pandemia más grave en los últimos 100 años. La afección es principalmente respiratoria y hasta 5 % de los pacientes desarrolla enfermedad crítica, lo cual ha producido una enorme presión sobre los sistemas de salud de los países afectados. Principalmente se ha observado alta demanda de atención en las unidades de cuidados intensivos y de recursos de atención vital. De ahí la necesidad de redistribuir los recursos en medicina crítica, con énfasis en la justicia distributiva, la cual establece atender al mayor número de personas y salvar el mayor número de vidas. Un principio estriba en asignar los recursos a pacientes con mayores expectativas de vida. Se ha dado por hecho que el ventilador mecánico es un bien indivisible; sin embargo, técnicamente es posible la ventilación mecánica simultánea a más de un paciente con COVID-19. La acción de compartir el ventilador no está exenta de riesgos, pero prevalecen los principios de beneficencia, no maleficencia y justicia. Conforme la justicia distributiva, al ser un bien divisible, el ventilador mecánico puede ser compartido, sin embargo, cabe preguntarse si esta acción es éticamente correcta.

PALABRAS CLAVE: COVID-19. Pandemia. SARS-CoV-2. Ventilación mecánica. Bioética.

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Introduction

The current pandemic caused by the SARS-CoV-2 coronavirus has exposed the limitation of health systems to provide adequate care to the population that has contracted this virus.¹ Pressure has been such in clinical areas, especially in those of critical medicine, that recommendations have been issued, based on the precept of distributive justice, for adequate administration of resources in critical medicine and thus care provision for the largest number of people and save, to the extent possible, the largest number of human lives.²⁻⁴ In this sense, and under this precept, fair and equitable distribution of limited resources in response to a growing demand in critical medicine areas has been one of the most pressing challenges to be met in current pandemic.⁵

Despite the recommendations for optimal distribution and administration of resources, a shortage of ventilators was observed in the first countries where the pandemic spread, owing to the high demand for patients with respiratory failure.⁶ Given the inability to slow down the flow of patients, classifying them through a triage process was necessary, which aims to allocate resources to individuals with the highest possibilities of survival, which makes for health personnel to be faced with an ethical conflict,⁶ with the inability of the health system to comply with distributive justice becoming evident.¹

Within this context, the General Public Health Council of Mexico, through the Ethics Committee of the Scientific Advisory Commission, brought together a group of experts and members who issued the *Bioethical guidelines for the allocation of limited critical medicine resources in an emergency situation*.² The purpose of this document is to provide criteria to guide triage decision-making when a public health emergency generates a demand for critical medicine resources that cannot be met. Faced with a scenario as the above-described, the Guidelines establish that "... scarce assets are those whose demand, in a given context of care, exceeds the number of assets in stock to be distributed...".² In turn, it is mentioned that these can be classified as divisible and indivisible. The former are "those that by their nature can be segmented and provide a fraction of their original usefulness to a specific group of patients (for example, the pill of a drug can be cut in two and each patient only receives half the therapeutic benefit..."). The latter (indivisible scarce assets), as its name indicates, are those that

"... owing to their nature cannot be segmented and only one patient can benefit from them in a given moment", for example, a dialysis machine. In this sense, the medical community generally considers mechanical ventilators among the latter.

Having said that, it is assumed that divisible assets do not generate an ethical conflict by sharing them between patients in an emergency.²⁻⁴ However, for the researchers of this article, the question persists on whether a mechanical ventilator is an indivisible asset.

COVID-19 pneumonia and its consequences on gas exchange in patients on mechanical ventilation

It has been more than evident that SARS-CoV-2 is highly contagious: global case fatality rate is 6.7 %. In addition to the large number of infected subjects, 5 % of patients have required intensive care attention and mechanical ventilation, in a sufficient proportion that has generated a shortage of resources in critical medicine areas, mainly of mechanical ventilators.⁶

SARS-CoV-2 causes the disease called COVID-19, which affects the respiratory system in five well-defined presentation forms, from an asymptomatic form or with mild symptoms in 80 % of the population, to a critical form in 5 % of cases. The severe form is observed in 15 % of patients as pneumonia, the clinical manifestations of which are cough, fever, dyspnea, and hypoxemia.⁷

Clinical presentation of the respiratory failure caused by COVID-19 has been documented to be progressive hypoxemia which, over the course of three to five days, can evolve to respiratory function severe impairment, the care of which requires mechanical ventilation and intensive care.⁵⁻⁷ The most critical expression of the disease is associated with 80 % mortality in those patients who experience it.

The mechanical ventilator as an indivisible asset in COVID-19

The mechanical ventilator is a medical device whose main function is to maintain an adequate gas exchange in patients who are disabled for it.⁸ So far, there is no specific treatment for COVID-19,⁷ however, mechanical ventilation is one of the main strategies to counteract the deleterious effects of respiratory failure observed in this disease.

Contrary to what is sought with distributive justice in cases of pandemic, mechanical ventilation in COVID-19

has been used as a palliative measure, since it only restores gas exchange while natural evolution of the disease takes place in a single patient.^{2,7} An expert opinion on the technical feasibility of simultaneously sharing a ventilator was recently published.⁸⁻¹⁰

The mechanical ventilator as a divisible asset to be shared in the same cycle

On March 24 of this year, the College of Physicians and Surgeons of Columbia University, in the United States, published a clinical practice protocol for shared ventilation: *Ventilator sharing protocol: Dual-patient ventilation with a single mechanical ventilator for use during critical ventilator shortages*.¹¹ This document describes the clinical indications and conditions by means of which two patients can share a ventilator; the risks and benefits the patients will be subjected to during the time they remain under shared ventilation and with sufficient safety measures are detailed in order for the events that occur to one patient not to affect the other.

Various groups have analyzed the technical possibility, establishing some considerations on the use of one ventilator for two patients as a last measure in case of shortage of mechanical ventilators.⁸⁻¹² In contrast, scientific associations of the United States issued a consensus in which they do not recommend the use of shared ventilation;^{13,14} they point at the concern of losing two lives in the attempt of saving one, assuming that the patient who agrees to share the ventilator can end up with harm and die.¹⁴ In mid-April, the United States Food and Drug Administration authorized the use of a low-cost device designed by the Yale University to be installed in a mechanical ventilator and provide safe ventilation to two patients with COVID-19 at the same time (maintaining the indications and recommendations for the case).¹¹

However, linking this topic with the types of assets in critical medicine in the face of the COVID-19 pandemic, shared assisted ventilation has been applied on more than one occasion both in medicine and in other situations, to give an example, in diving: in the event that one diver runs out of air, a second diver can share his air tank and both can efficiently reach the surface with a reasonable degree of safety. In medicine, the best example is mouth-to-mouth or mouth-mask ventilation, a widely accepted exercise in basic support procedures and advanced life support, in which one subject provides positive pressure ventilation, through his own breathing, to another one who

presents with respiratory or cardiorespiratory arrest (the so-called "kiss of life"). It is important to highlight that this type of support is temporary while spontaneous ventilation is restored or, otherwise, until it is replaced by a mechanical ventilator. In both examples, not sharing ventilation would have immediate dire results.

Under the assumption that units that receive patients with COVID-19 have a protocol for sharing ventilators in the event they are not available for patients with severe respiratory failure due to this disease, the following example sets forth the precepts of distributive justice: there is no mechanical ventilator available for a patient with confirmed COVID-19 (patient 1), whose respiratory condition has deteriorated to such a degree that the supplied oxygen supplement is not sufficient to palliate hypoxemia and, although he is not in a terminal condition, evidently requires endotracheal intubation, sedation-analgesia, and ventilatory mechanical support. According to the resource availability guidelines,² it is necessary to assess those patients who are on mechanical ventilation and, according to the triage procedure, determine who will have the resource (ventilator) withdrawn to give it to that first patient. What options does the triage team have for this case?

1. Patient 1 is in the same disease conditions than ventilated patients; therefore, the triage committee decides to mitigate the suffering with palliative sedation administration, with the possibility that the patient will experience respiratory arrest, either due to respiratory failure, palliative sedation, or both. End result: the patient dies.
2. According to different prognostic scales (none specific for COVID-19), the triage team determines to withdraw the ventilator and provide palliative sedation to a patient who shows a higher score that denotes "poor prognosis" (patient 2) to provide it to patient 1, who has better chances of survival. It is highly likely that patient 2 will experience respiratory arrest due to respiratory failure, palliative sedation, or both. End result: patient 1 stays alive and patient 2 dies.
3. The triage team determines that patient 2 has a similar or comparable scenario to that of patient 1, and thus they decide to ventilate both simultaneously (a situation not described in the guidelines, but technically possible). The result then is that patient 1 receives the oxygen and ventilatory support necessary to mitigate respiratory failure distress and counteract the deleterious effects of

hypoxemia, thereby improving oxygenation and arterial saturation. Patient 2 maintains the lung function he had prior to sharing the ventilator. Both ventilated patients have the same probability of dying (60 to 80 %). The measure is temporary while the lung function of one or both patients is restored or a mechanical ventilator becomes available to separate them.

During mechanical ventilation with the dual system, patients can exhibit the following evolution:

- a) Patient 1 dies from severe COVID-19 pneumonia and patient 2 stays alive with a high probability of dying despite mechanical ventilation.
- b) Patient 1 stays alive, with a high probability of dying despite mechanical ventilation. Patient 2 dies from severe COVID-19 pneumonia.
- c) Patient 1 dies as patient 2 also does. In both cases, the cause of death is severe COVID-19 pneumonia.
- d) Patient 1 survives until his lung function is restored, as patient 2 also does.

In the example, scenarios a and b show one of the most widely used bioethical arguments under the utilitarian concept that it is “better” to save one than none, and that it is therefore preferable providing support to those who are more likely to survive, while scenarios c and d show that when sharing a divisible asset there is the possibility that one or both patients will survive.

Distributive justice is a concept that is applied in public health for emergencies and when limited resources must be managed in such a way that the highest number of people can be cared for and the highest number of lives can be saved.^{1,2} According to this principle, sharing a mechanical ventilator is ethically correct in the absence of said resource during an emergency.

The action of sharing the mechanical ventilator is based on the egalitarian concept that each person should be treated the same according to his/her needs (equal treatment for equal need). Relieving the suffering of respiratory failure in both patients keeps them alive with an equal probability of survival immediately after endotracheal intubation and at the beginning of mechanical ventilation.¹ With appropriate care, it is possible for both patients to stay alive until an available mechanical ventilator is found or respiratory failure is resolved in one of them. This way, the principle of caring for the highest number of patients is complied with and the possibility of saving more lives is broadened, preserving the possibility of higher life expectancy in each patient, without discriminating either one.¹⁵

In clinical practice, regardless of the social good that is subjected to public health, sharing the ventilator complies with the Hippocratic principle of “first do no harm” and preserves the principles of beneficence and non-maleficence. When a ventilator is shared, lung function is totally or partially reestablished (depending on the degree of lung involvement of the patients, who are in principle comparable) by gas exchange in both patients (beneficence). However, there are inherent risks^{13,14} that can affect the patient who “shares” (for example, infections other than COVID-19, inequity in gas distribution in the lungs, etc.), but the fact that both patients receive the same treatment (non-maleficence) prevails. Thus, primary objectives such as mitigating the suffering caused by respiratory failure of the patient who receives the benefits of the shared resource are also met.

The precept of distributive justice is maintained by sharing mechanical ventilation, since the resource is optimized by serving a larger number of people (two patients with one ventilator) and tacitly doubling the number of available ventilators in case of shortage thereof. The second principle of saving the largest number of lives is also complied with, since by preventing one or the other patient from dying of asphyxia, both remain alive with the same resources and the same outcome probability.

Conclusion

In accordance with the principle of distributive justice that prevails in pandemic cases, a mechanical ventilator can be considered a divisible asset and be shared by at least two patients at the same time. This measure serves the largest number of people with the same probability of saving a larger number of people.

Conflict of interests

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Ethical disclosure

Protection of people and animals The authors declare that no experiments were performed on humans or animals for this investigation.

Confidentiality of data The authors declare that they followed the protocols of their work place on the publication of patient data.

Right to privacy and informed consent The authors declare that no patient data appear in this article.

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