

Discourse on emergency ventilation

This document shows the current state of knowledge regarding emergency ventilator use. We built the IST Emergency Ventilator on basis of the MIT e-vent project (<https://e-vent.mit.edu/>). Please also check regularly on the MIT project site to get the latest information on the project and on ventilation with COVID-19 patients in particular.

Since there is ambiguity in public information on the level of usefulness of emergency ventilators, we see it as our responsibility to add these voices and concerns to the project. Everyone expanding on our work should be aware of these opinions to make their own decisions.

1. **Ventilator design based on conventional self-inflating bag systems.** Scientists at the Medical University of Graz did a brief animal study on such a design and came to the following conclusion:

"We carried out experiments on large animals together with representatives of the pulmonology of the LKH Univ. Graz. In the course of the experiment, it quickly became apparent that the small volume of the bag is not sufficient for optimal CO₂ elimination or limits it. The respiratory rate should be so high that sensible ventilation over a longer period of time would hardly be possible. Another challenge is the FiO₂ setup. This is difficult to achieve with a reservoir, which is designed to enrich the gas with high O₂ values. Wear, the tightness of the PEEP valve, etc. were also problems which we were confronted with. All these reasons have led us to decide to refrain from the bag design variant.

The following volumes would need to be achieved: Tidal volume 6-8ml / kg body weight. Regarding a volume per minute, a reserve of at least 20L - better 30L - should be reached. This means that values of approx. 1200ml-1500ml would have to be reached via tidal volume in order to achieve a volume with a temporally possible respiratory rate."

2. **Ventilators must be used with care and operated solely by medical experts.** There seems to be indications that corona patients in the intensive care units could die from positive pressure ventilation. Especially if the patient has been intubated beforehand. Some hospitals have reported unusually high death rates for coronavirus patients on ventilators, and some doctors worry that the machines could be harming certain patients.

https://www.vpneumo.de/fileadmin/pdf/VPK_Empfehlung_neu_21.03.2020.pdf (German)

https://www.medscape.com/viewarticle/928156?scr=soc_yt_200311_mscpedt_news_mdspc_COVIDJOHN&faf=1

<https://www.youtube.com/watch?v=Ykp0H8DengQ>

<https://apnews.com/8ccd325c2be9bf454c2128dcb7bd616d>

[https://www.thelancet.com/journals/lanres/article/PIIS2213-2600\(20\)30079-5/fulltext](https://www.thelancet.com/journals/lanres/article/PIIS2213-2600(20)30079-5/fulltext)

https://www.nejm.org/doi/full/10.1056/NEJMoa2004500?query=featured_home

3. Current state of knowledge:

- Doctors and medical personnel do not have enough information on the specifics of COVID-19 yet to make fully informed decisions.
- We know, even before COVID-19, that all forms of ventilation, per se, are to some extent "hostile" to the human body. We know that ventilation in general can do harm if not applied correctly.
- We know that ventilation should be carried out as low as possible and as gently and as briefly as possible - always. No matter whether COVID-19 or not.
- We ventilate when the patient himself has no strength to breathe (muscle) or gas exchange (CO₂ from the blood into the lungs and from there into the exhaled air, or O₂ in the inhaled air into the lungs and from there into the blood) works enough. Whatever the reason. The indication for ventilation is given if certain oxygen partial pressures in the blood in relation to the oxygen percentage of the inhaled air cannot be maintained and / or CO₂ is not exhaled sufficiently (be it from muscle failure or gas exchange problems).
- Ventilation without a ventilation hose using a special mask (non-invasive ventilation) also needs a ventilator, a sophisticated one.
- Altitude sickness, in relation to the video above (see point 2), and drops in oxygen partial pressure in the blood are treated with overpressure.
- COVID-19, is a disease that can lead to measured lung failure (muscle and or gas exchange) for currently unexplained causes.
- Ventilation, whether invasive with a breathing tube or non-invasive with a helmet or mask, replaces organ function. It does not treat the disease.
- In some cases, non-ventilation leads to death. Every doctor will give the indication for ventilation conscientiously.
- The indication, for ventilation, has nothing to do with the project. The indication for ventilation is at the discretion of the doctor and not the developer or manufacturer of a (sensible, simple) ventilator.

We developed the ventilator consulting three medical professionals and experts in artificial respiration. All of them agree that the device we built is making a meaningful contribution to medical treatment. Here some main feedback and improvement points:

- Very encouraging project, fulfills all necessary medical functions for emergency use
- Main suggestions for important improvements (all implemented to date):
 - with a duration of the inspiration phase of 2sec, increase in flow rate from 0 to 30 l / min within the first second, then constant at 30 l / min
 - pressure vs. volume control: preference for pressure control, i.e. Isolation of inspiration at freely selectable pressure, e.g. 20millibar, max 30millibar, regardless of the air volume
 - Installation of PEEP valve to ensure a positive end-expiratory pressure after the expiration phase (residual pressure in the lungs)
 - For longer use, humidification and heating of the air after the bag
- Main suggestions for nice-to-have improvements (not implemented yet):
 - Lid and housing for better disinfection
 - Build it smaller

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- Bigger display showing pressure curve and current settings
- Flow measurement in the tube – systems commercially available
- Mechanic stress of bag should be taken into consideration – replacement guideline