

Project to expand the capacity of existing commercial ventilators

Buenos Aires, Argentina

Objective

Create a low complexity kit that temporarily expands the capacity of existing commercial fans up to four times to deal with an emergency that saturates the number of available ventilators.

Background

The expansion of ventilator capacity through the use of flow dividers has been used despite not being extensively documented in scientific publications and always in the context of an emergency.

In 2006 in Detroit, USA, Dr. Greg Neyman and Dr. Charlene Babcock Irvin conducted a 12-hour trial with a ventilator attached to four lung simulators. The test yielded satisfactory results obtaining correct oxygenation of the four lung simulators. However, the tested system has the following limitations: each patient cannot be individualized, all patients must have a similar respiratory capacity (lung size, respiratory conditions, etc.) in order to obtain the same oxygen flow and there may be risk of cross contamination [1].

In New York, USA in 2007, Dr. Paladino and his team, based on Neyman and Irvin's experiment, conducted a study connecting four sheep to a ventilator for 12 hours. All the sheep had a capacity comparable to that of an adult of 70 kilograms. As with the Neyman and Irvin's experiment, satisfactory results and the same limitations were observed [2].

In 2009 in Bath, UK, Drs Smith and Brown conducted a 10-minute study with a pulmator for two patients. No complications were observed and they confirmed the viability of the solution proposed by Paladino to be performed during emergencies [3].

In 2013 in Bologna, Italy, Dr. Bellini's team used a pulmator to transport twins from the outskirts of the city to the hospital. This technique was successfully used to transport 96 twins. The average duration of the trip was two and a half hours [4].

On October 1, 2017, during a music festival in Las Vegas, USA, a man shot dead, killing 58 people and injuring 413 others. In this tragic event, the health system collapsed. Dr. Menez used a ventilator for two people for several hours until they received the equipment from other cities. The patients saved their lives and no adverse results were observed during this procedure [5] [6].

In the context of the COVID-19 crisis, several doctors from different parts of the world are considering using this type of solution [7] [8]. In Chru Brest, France, Dr. Erwan L'Her created a protocol for the use of a ventilator for up to four patients [9]. It has been translated into Spanish by the College's Medical and Sanitary Engineering Commission and the Association of Industrial Engineers of Madrid [10].

In New York, experimental use of a ventilator for two patients has begun experimentally [11] as of March 28 at the request of Governor Cuomo [12].

The kit developed is based on the information previously presented and overcomes the limitation that all patients connected to the ventilator must have the same lung capacity using a flow regulator per patient. In addition, it has antibacterial filters in order to avoid cross contamination and passive humidifiers.

The project contemplates the development of a mobile app (Android and iOS) that also allows monitoring the patients remotely.

Argentina: Equipment and status

As of March 27, 2020, according to official estimates in our country, there are about 8,500 beds with ventilators, of which only about 1,700 are available, since the rest are occupied [13].

The Ministry of Health bought all the ventilators available in the market (a total of 64 units) and they intend to acquire all the production of the three Argentine ventilator factories during the next two months, at a rate of 200 per week, giving a total of 1600 units [14].

On the other hand, President Alberto Fernández placed an order with China for about 1500 items [14]. It should be noticed that these shipments are usually delayed as it is happening with the 200 ventilators ordered by the City of Buenos Aires.

The optimistic scenario results in a total of 4864 ventilators.

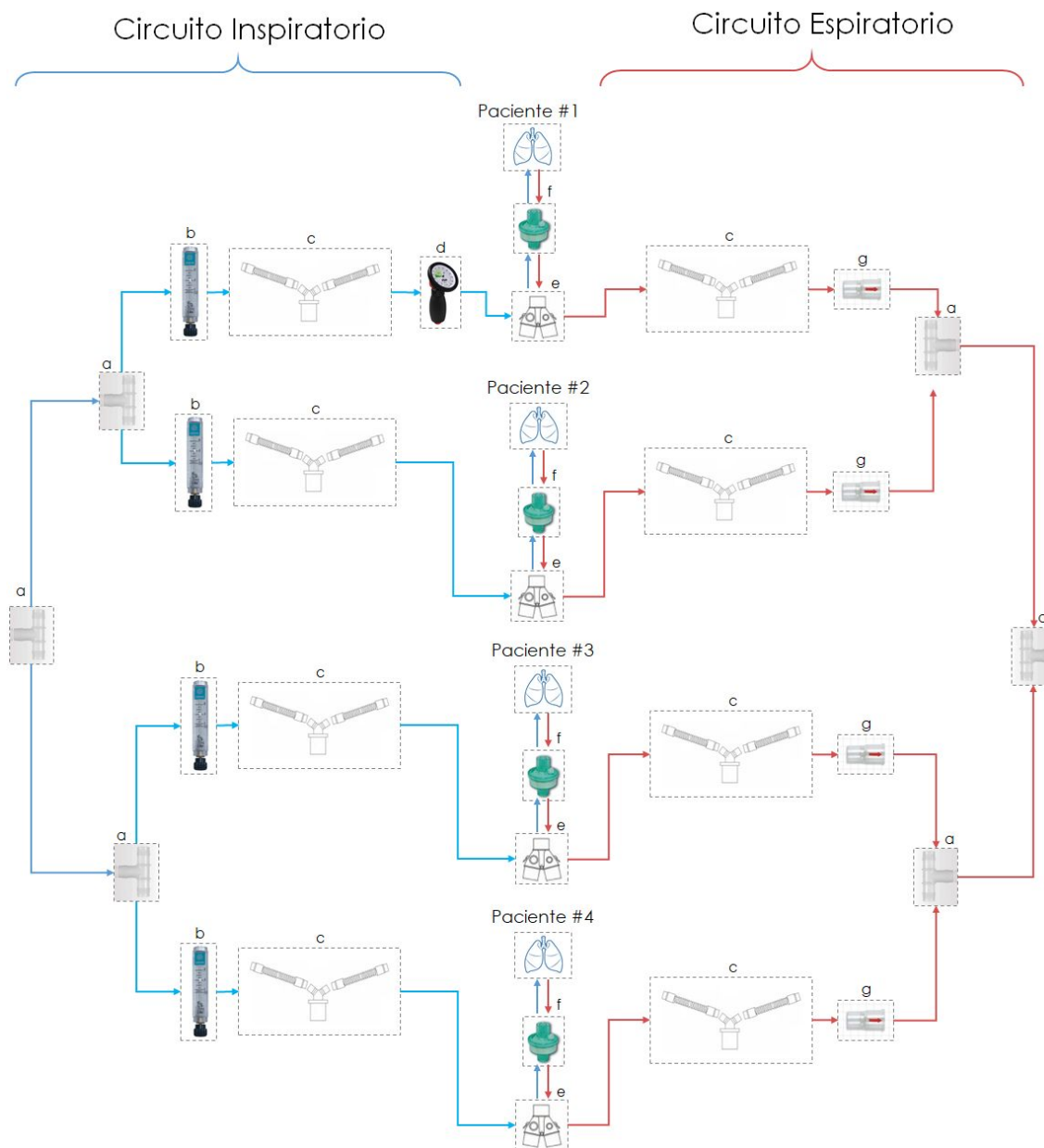
Estimates of infections by the Argentine government range between 200,000 and 2.2 million infected during the coming infections peak [15]. Of the infected people, only 5% require intensive care - between 10,000 and 110,000 people [8]. Given this scenario, there may be a shortage of units and medical personnel may find themselves in the dilemma of having to choose who to connect, as has happened in northern Italy [16]. To ease the burden of this possible scenario, the kit proposed presents an alternative solution in the state of emergency.

Budget

The development of the kit and the app is estimated at US \$ 5,000.

Each unit (kit+app) will cost approximately US \$ 500.

Design details



Design Considerations

The in-development kit has the following considerations:

The system can have a maximum of 4 patients

All patients must be sedated and have neuromuscular blockers (BNM) in order not to compete with the ventilator.

All patients receive the same gas mixture.

Capnography capabilities are not available for every patient.

The kit works in conjunction with a mobile app (also in development) that makes possible to monitor Tidal Volume in patients remotely. App will be available for Android and IOs devices.

All patients have the same PEEP (Positive pressure at the end of expiration).

The system works by pressure control (PCV) so it does not allow transition to PSV (support pressure) and weaning.

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