Advances in the methodology of co-ventilation during a disaster

Charlene Irvin Babcock [1], Lorenzo Paladino[2,3]

The study by Tonetti *et al*[1] describes a potential configuration for the invasive ventilation of two adults on one ventilator ('co-venting'). This is a similar configuration to those previously published in 2006 by Neyman and Irvin (four test lungs on one ventilator),[2] and evaluated both in 2008 by Paladino *et al*[3] (using normal lungs in sheep, ventilating four on one ventilator) and again by Branson *et al*[4] in 2012 (with different respiratory system compliance and airways resistance in four tested lungs on one ventilator). This concept was also explored using face masks (non-invasive ventilation) in two human volunteers for 10 min by Smith and Brown in 2009.[5] In 2017, Keven Menes used this previously evaluated 'splitting' of ventilators and implemented it during a mass shooting in Las Vegas, when a sudden influx of injured patients caused an acute ventilator shortage.[6] This mass casualty event revealed its first successful use in humans (two patients on one ventilator), although this experience has not been published in a peer-reviewed journal.

This research and proof of concept by Neyman, Irvin[2] and Paladino *et al*,[3] were not meant to endorse the use of co-venting on four patients exclusively. Rather the aim was to show the scalability of the procedure in a disaster. If four patients can be ventilated with one machine, the same approach can certainly be applied to two patients on a single ventilator. Indeed, the US Health and Human Services has released several documents pertaining to co-venting including the COVID-19 Task Force guidelines which described one potential method of co-venting if it were to become necessary.[7]

On 14 March 2020, a Youtube video was launched by one of the authors (CIB) showing the set-up for ventilating four test lungs on one ventilator, and also revealed the set-up for two test lungs on one ventilator.[8] This information, along with the previously published articles regarding this process,[2 3] was shared with physicians at various Italian universities by one of the authors (LP) in early March as they struggled with how to address the ventilator shortage. This led to the manuscript published by Tonetti *et al*, which shows in more detail the two patient on one ventilator configuration.[1]

There have been considerable recent advances and insight into this potential approach as the COVID-19 pandemic continues to challenge those managing patients needing ventilatory assistance with limited ventilator resources. While some societies have raised concern about the lack of human experience in diseased lungs (Menes use in humans had mostly normal lungs)[6] and recommend against it,[9] other institutions have explored it as an option in dire circumstances and published their recommended methodology.[10]

Everyone agrees one patient on one ventilator will always be the gold standard. Use of one ventilator for two patients is clearly outside the manufacturer's recommendations and only appropriate in dire circumstances during a disaster. Understanding the background, parts needed, set-up configuration and implementation procedure options will assist those who may need this novel approach to expand ventilator options. We commend the authors of this study for further advancing documentation of this potential expansion of ventilator availability as a life-saving intervention during a disaster and hope the additional information we have provided may be informative.

Contributors Both authors contributed to the manuscript and edits.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Commissioned; internally peer reviewed.

Data availability statement No data are available. No data. is reported.

[1]Department of Emergency Medicine, Ascension St John Hospital and Medical Center, Detroit, Michigan, USA
[2]Department of Emergency Medicine, State University of New York Downstate Medical Center, Brooklyn, New York, USA
[3]Department of Emergency Medicine, Kings County Hospital Center, Brooklyn, New York, USA

Correspondence to Dr Charlene Irvin Babcock, Department of Emergency Medicine, Ascension St. John Hospital and Medical Center, Detroit, MI 48374, USA; charlenebabcockmd@gmail.com

To cite Irvin Babcock C, Paladino L. *Thorax* 2020;**75**:448.

Received 6 April 2020
Revised 7 April 2020
Accepted 8 April 2020
Published Online First 19 April 2020

► http://dx.doi.org/10.1136/thoraxjnl-2020-214895
► http://dx.doi.org/10.1136/thoraxjnl-2020-214929

Thorax 2020;**75**:448.
doi:10.1136/thoraxjnl-2020-214967

ORCID iD
Charlene Irvin Babcock http://orcid.org/0000-0002-0157-7317

REFERENCES

1 Tonetti T, Zanella A, Pizzilli G, *et al*. One ventilator for two patients: feasibility and considerations of a last resort solution in case of equipment shortage. *Thorax* 2020;75:517–9.
2 Neyman G, Irvin CB. A single ventilator for multiple simulated patients to meet disaster surge. *Acad Emerg Med* 2006;13:1246–9.
3 Paladino L, Silverberg M, Charchaflieh JG, *et al*. Increasing ventilator surge capacity in disasters: ventilation of four adult-human-sized sheep on a single ventilator with a modified circuit. *Resuscitation* 2008;77:121–6.
4 Branson RD, Blakeman TC, Robinson BR, *et al*. Use of a single ventilator to support 4 patients: laboratory evaluation of a limited concept. *Respir Care* 2012;57:399–403.
5 Smith R, Brown JM. Simultaneous ventilation of two healthy subjects with a single ventilator. *Resuscitation* 2009;80:1087.
6 Menes K, Tintinalli J, Plaster L. How one LAS Vegas ED saved hundreds of lives after the worst mass shooting in U.S. history, 2017. Available: https://epmonthly.com/article/not-heroes-wear-capes-one-las-vegas-ed-saved-hundreds-lives-worst-mass-shooting-u-s-history/ [Accessed 6 Apr 2020].
7 U.S. Public health service commissioned Corps, 2020. Available: https://www.hhs.gov/sites/default/files/optimizing-ventilator-use-during-covid19-pandemic.pdf
8 Charlene Irvin Babcock. How to use one ventilator to save multiple lives. Available: https://www.youtube.com/watch?v=uClq978oohY [Accessed 14 Mar 2020].
9 The Society of Critical Care Medicine, American Association for Respiratory Care, American Society of Anesthesiologists, Anesthesia Patient Safety Foundation, American Association of Critical-Care Nurses, American College of Chest Physicians. Joint statement on multiple patients per ventilator, 2020. Available: https://www.asahq.org/about-asa/newsroom/news-releases/2020/03/joint-statement-on-multiple-patients-per-ventilator [Accessed 6 Apr 2020].
10 Beitler JR, Kallet R, Kacmarek R, *et al*. Ventilator sharing protocol: Dual-Patient ventilation witha single mechanical ventilator for use during critical ventilator shortage, 2020.Available: https://protocols.nyp.org [Accessed 6 Apr 2020].

Simple ‘do it yourself’ circuit to ventilate two patients at once is technically feasible

But still not known if split ventilation pros outweigh cons so should only be used as last resort, say specialists

A simple ‘do it yourself’ breathing circuit, using accessories that are readily available in intensive care, can be used to ventilate two critically ill patients at once, should clinicians be faced with equipment shortages, suggests research published online in the journal ***Thorax***.

But although technically feasible, it isn’t clear if the pros of split ventilation outweigh the cons, and the approach is fraught with ethical issues, so this circuit should only be used as a last resort, say critical care and respiratory disease doctors in linked opinion pieces.

Prompted by the rapid rise in COVID-19 cases in the Lombardy region of Italy, and the prospect of a ventilator shortage, Italian doctors assembled and tested a simple, easily built breathing circuit on two ‘pretend’ patients.

The circuit comprised routine and readily accessible tubing and accessories found in intensive care and operating theatres.

The 15-hour tests confirmed that it would be technically feasible to use the circuit to ventilate two patients at the same time.

What’s more, the technique is safer for staff than manual bag ventilation and avoids the constant need for a ‘human ventilator’ to work the bag, so freeing up staff, say the researchers.

But the tests also showed that the level of ventilation provided wasn’t evenly distributed when lung function and capacity differed between the two ‘patients.’

It should therefore only be used as a last resort, caution the researchers, because of the need to closely match the physiology of both patients, and the impossibility of being able to monitor separately changes in each patient’s respiratory response.

There are also ethical issues to consider, they point out. “Indeed, the most difficult choice during such an emergency would be to either accept a grim triage reality (in which not all patients receive a ventilator), or accept the fact that trying to save two patients with one ventilator could mean harming at least one of them,” they write.

These concerns are picked up in a linked editorial by respiratory disease and critical care doctors from the University of Chicago.

The idea of ventilator sharing isn’t new, explain Drs Steven Pearson, Jesse Hall, and William Parker. It was first suggested in 2006, for coping with equipment shortages in dire emergencies, and has been revived in anticipation of ventilator supply problems during the COVID-19 pandemic.

But they warn that even if patients can be matched before ventilation, the dynamic nature of the respiratory response means that these initial characteristics could subsequently diverge.

Daily pauses in the sedation needed for mechanical ventilation to check on the patient’s

ability to breathe unaided--which seems to help patients recover--would be extremely difficult if two people were connected to the same device, they point out.

The technical challenges also require other resources in short supply: intensivists and respiratory therapists, they say.

During a severe equipment shortage, clinical decisions would need to be based on ensuring the greatest good for the greatest number of patients, they explain. But what would happen if two patients each had a 50% chance of survival with a single ventilator, but only 20% on split ventilation, they ask?

“Whether or not the benefit of providing support to one additional patient outweighs the harms suffered by the two patients receiving co-ventilation is an impossible question to answer at this point, given the lack of evidence and experience, and these harms are unlikely to be amenable to rigorous quantification at any point in the near future,” they write.

Ideally, in the absence of adequate supply, or other breathing support devices, patient (and family) consent should be obtained and strict protocols applied for the circumstances in which split ventilation can be used, and then only as a last resort, they emphasise.

“The role for co-ventilation appeals to the rule of rescue, the natural impulse to save those facing certain death, by freeing mechanical ventilators to support those in respiratory failure who would die without them,” they write.

“But to use the lifeboat analogy, is taking on more passengers than the boat was designed to accommodate, worth the risk of sinking the lifeboat?”

Given current supply and demand, doctors will most likely be faced with such decisions, they suggest. “Humankind should realise it has been forced into a lifeboat by this pandemic without the luxury of yesterday’s ethical postures until rescue arrives,” they conclude.

In a further linked commentary, emergency care doctors in Detroit and New York agree that one patient per ventilator is best. Their YouTube video, setting out the experimental technique for ventilating four patients at the same time, inspired the Italian doctors to experiment with the approach for two patients.

“Everyone agrees one patient on one ventilator will always be the gold standard,” write Drs Charlene Babcock and Lorenzo Paladino. “Use of one ventilator for two patients is clearly outside the manufacturer’s recommendations and only appropriate in dire circumstances during a disaster.”

But reporting on further experiences of the technique can only assist the understanding of how to expand ventilator options, they suggest.

“We commend the [Italian] authors of this study for further advancing documentation of this potential expansion of ventilator availability as a life-saving intervention during a disaster and hope the additional information we have provided may be informative,” they conclude.