

PDF hosted at the Radboud Repository of the Radboud University Nijmegen

The following full text is a publisher's version.

For additional information about this publication click this link.

<https://hdl.handle.net/2066/220518>

Please be advised that this information was generated on 2021-04-12 and may be subject to change.

RESEARCH LETTER

Open Access

Advanced respiratory monitoring in COVID-19 patients: use less PEEP!



Lisanne Roesthuis*, Maarten van den Berg and Hans van der Hoeven

Keywords: Coronavirus disease 2019, Acute respiratory distress syndrome, Positive end-expiratory pressure, Lung compliance, Dead space ventilation, Hyperinflation

To the Editor,

In the majority of coronavirus disease 2019 (COVID-19) patients, respiratory mechanics is different from the “normal” acute respiratory distress syndrome (ARDS) patient. Plateau pressures and driving pressures are often low and respiratory system compliance relatively normal compared to the ARDS patient [1]. Many physicians use high positive end-expiratory pressure (PEEP) for patients with COVID-19 although the potential for recruitment is often low [1, 2]. We fear that the high compliance of the respiratory system in combination with high PEEP will lead to hyperinflation, high dead space, and potentially right ventricular failure.

We have used the following strategy for COVID-19 patients ($N = 70$): after intubation, immediately prone positioning for at least 3 days, using the lowest possible PEEP to obtain adequate oxygenation with FiO_2 of 50%. We assessed the effects of different PEEP levels on respiratory mechanics and ventilation-perfusion mismatching.

Methods

Respiratory mechanics was assessed in COVID-19 patients admitted to the Radboud University Nijmegen Medical Center as part of standard patient care. Brief occlusions were performed to assess end-inspiratory and end-expiratory airway and transpulmonary pressures (absolute and elastance ratio method) and to calculate respiratory and lung compliances as previously described

[3, 4]. Dead space ventilation was assessed using two methods:

- 1) The Bohr equation using partial pressure of carbon dioxide in alveolar air (PACO_2) and mixed expired air (PeCO_2): $(\text{PACO}_2 - \text{PeCO}_2)/\text{PACO}_2$. See our previous work for detailed description [5].
- 2) The Enghoff modification of Bohr’s equation using partial pressure of carbon dioxide in arterial blood (PaCO_2): $(\text{PaCO}_2 - \text{PeCO}_2)/\text{PaCO}_2$. Therefore, shunt and diffusion limitations are taken into the equation.

Results

Advanced respiratory mechanics was assessed in 14 patients (8 males and 6 females, age (mean \pm SEM) 67 ± 2 years, body mass index $28.0 \pm 0.9 \text{ kg/m}^2$) between the 19th of March and 2nd of April (Table 1). Compliance of the respiratory system was low ($42 \pm 3 \text{ mL/cmH}_2\text{O}$) due to a lower than normal lung compliance ($61 \pm 5 \text{ mL/cmH}_2\text{O}$). However, compared to ARDS patients, lung compliance was relatively high, resulting in low end-inspiratory transpulmonary pressures ($12 \pm 1 \text{ cmH}_2\text{O}$). Chest wall compliance was slightly lower than normal due to prone positioning in most patients. COVID-19 patients had high dead space ventilation and gas exchange impairment (Bohr $52 \pm 3\%$; Enghoff modification $67 \pm 2\%$).

Reducing PEEP resulted in an increase in lung compliance and decrease in dead space ventilation, except for patient 1 (Fig. 1).

* Correspondence: Lisanne.Roesthuis@Radboudumc.nl

Department of Intensive Care Medicine, Radboud University Medical Center, Geert Grooteplein-Zuid 10, 6525 GA Nijmegen, The Netherlands

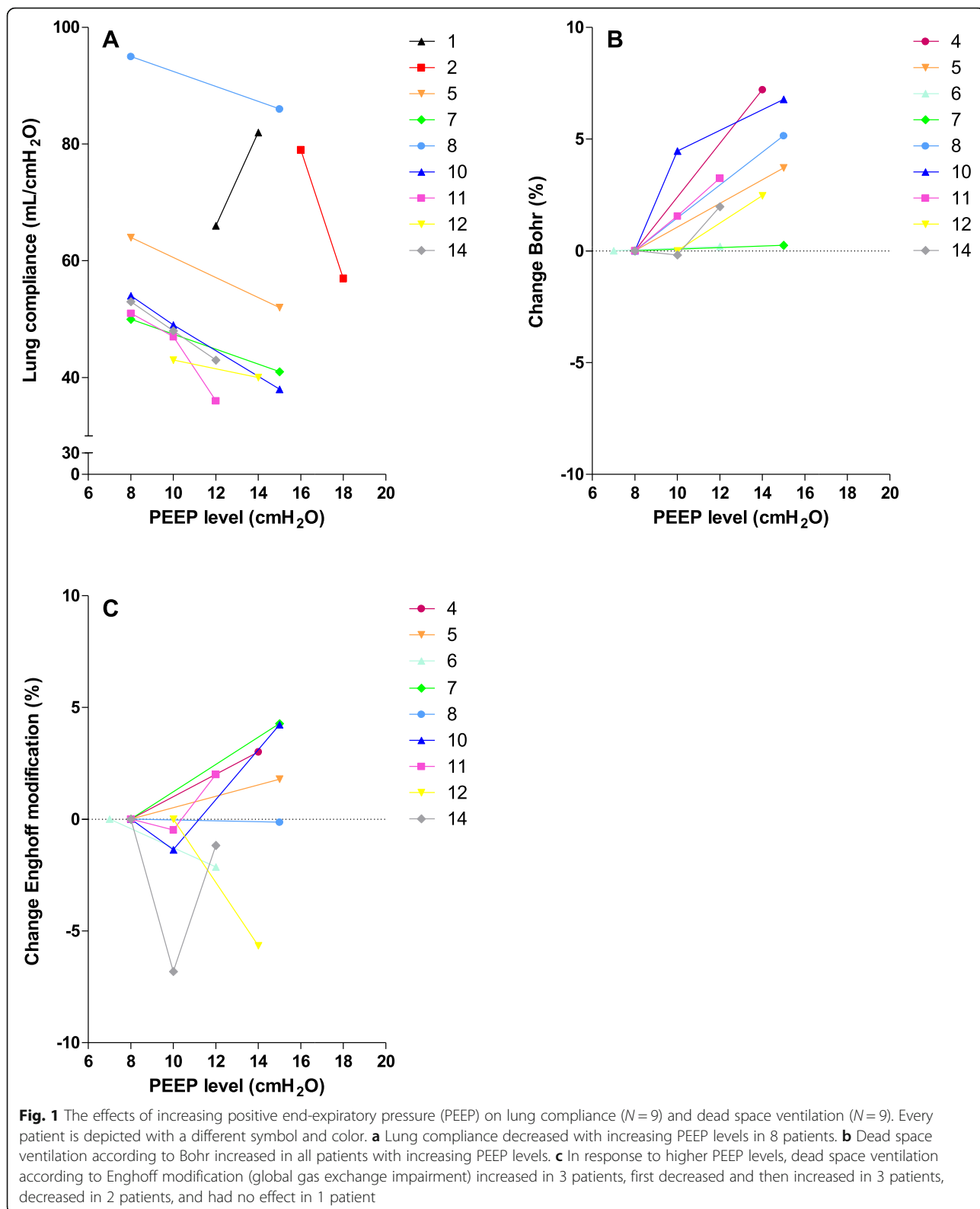


© The Author(s). 2020 **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

Table 1 Respiratory mechanics

Patient no.	MV days	FiO ₂	PaO ₂ /FiO ₂ (mmHg)	PaCO ₂ (mmHg)	P_{plateau} (cmH ₂ O)	P_{drive} (cmH ₂ O)	$P_{L,e-i}$	$P_{L,drive}$ (cmH ₂ O)	C_{rs} (mL/cmH ₂ O)	C_L (mL/cmH ₂ O)	Enghoff (%)	Bohr (%)	Position
1	7	0.50	156	87	22	8	9	5	55	82	–	–	P
2	2	0.45	208	56	24	7	17	18	54	79	–	–	S
	3	0.55	124	57	26	8	–	–	48	–	66	47	S
3	0	0.50	228	44	23	9	17	16	47	62	66	56	S
4	1	0.60	123	44	–	–	–	–	–	–	71	58	P
5	0	0.40	214	48	23	13	9	9	40	54	55	42	P
	1	0.40	278	44	18	10	7	8	50	64	48	38	P
6	1	0.45	143	49	–	–	–	–	–	–	63	40	P
7	1	0.55	183	55	23	14	11	10	36	50	60	42	P
8	1	0.40	176	52	16	8	7	5	56	95	64	51	P
9	0	0.95	98	61	29	12	14	9	38	50	–	–	P
	5	0.60	143	89	27	12	14	9	35	45	72	60	P
10	1	0.80	125	53	21	10	11	7	36	49	66	52	P
11	2	0.55	147	49	21	12	11	10	40	51	69	47	P
12	2	0.75	113	59	25	11	11	8	26	37	69	57	P
	3	0.65	111	47	26	12	11	8	27	40	71	60	P
13	1	0.50	192	67	24	12	10	7	47	76	82	74	P
14	6	0.70	150	62	28	15	15	11	31	43	65	52	P

C_{rs} compliance of respiratory system, C_L lung compliance, *MV days* days of mechanical ventilation at the time of measurement, $P_{L,e-i}$ end-inspiratory transpulmonary pressure, $P_{L,drive}$ transpulmonary driving pressure, *P* prone position, *S* supine position



Discussion

We demonstrate that mechanically ventilated patients with COVID-19 have a relatively high lung compliance, high dead space ventilation, and gas exchange impairment. In almost all patients, lung compliance decreased and dead space ventilation increased with increasing PEEP levels.

The decrease in lung compliance and increase in dead space ventilation in response to higher PEEP levels indicate that COVID-19 lesions were not recruited and that higher PEEP levels cause hyperinflation of the more compliant parts of the lung [1]. These results are in accordance with recent findings in COVID-19 patients [2].

When lung compliance increases in response to higher PEEP levels (patient 1), recruitment is likely and PEEP should be set accordingly [1, 2].

All patients responded extremely well to prone positioning, although the exact mechanism is unclear. Redistribution of blood flow seems to be an important mechanism.

In conclusion, we show that higher PEEP levels decrease lung compliance and in most cases increase dead space ventilation, indicating that high PEEP levels probably cause hyperinflation in patients with COVID-19. We suggest using prone position for an extended period of time (e.g., 3–5 days) and apply lower PEEP levels as much as possible.

Abbreviations

ARDS: Acute respiratory distress syndrome; COVID-19: Coronavirus disease 2019; PACO_2 : Partial pressure of carbon dioxide in alveolar air; PaCO_2 : Partial pressure of carbon dioxide in arterial blood; PeCO_2 : Partial pressure of carbon dioxide in mixed expired air; PEEP: Positive end-expiratory pressure; SEM: Standard error of the mean

Acknowledgements

Not applicable.

Authors' contributions

Data acquisition: LR. Data analysis: LR. Data interpretation: all authors. Manuscript drafting and revising: all authors. The authors read and approved the final manuscript.

Funding

There was no financial funding.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Due to standard patient care and the urgent need to gain knowledge about this new lung disease, informed consent was deemed unnecessary, but also not feasible in most cases.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Received: 28 April 2020 Accepted: 7 May 2020

Published online: 15 May 2020

References

- Gattinoni L, Chiumello D, Caironi P, Busana M, Romitti F, Brazzi L, et al. COVID-19 pneumonia: different respiratory treatments for different phenotypes? *Intensive Care Med.* 2020. Epub ahead of print.
- Pan C, Chen L, Lu C, Zhang W, Xia JA, Sklar MC, et al. Lung Recruitability in SARS-CoV-2 associated acute respiratory distress syndrome: a single-center, observational study. *Am J Respir Crit Care Med.* 2020. Epub ahead of print.
- Akoumianaki E, Maggiore SM, Valenza F, Bellani G, Jubran A, Loring SH, et al. The application of esophageal pressure measurement in patients with respiratory failure. *Am J Respir Crit Care Med.* 2014;189(5):520–31.
- Yoshida T, Amato MBP, Grieco DL, Chen L, Lima CAS, Roldan R, et al. Esophageal manometry and regional transpulmonary pressure in lung injury. *Am J Respir Crit Care Med.* 2018;197(8):1018–26.
- Doorduyn J, Nollet JL, Vugts MP, Roesthuis LH, Akankan F, van der Hoeven JG, et al. Assessment of dead-space ventilation in patients with acute respiratory distress syndrome: a prospective observational study. *Crit Care.* 2016;20(1):121.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

