Intensive Care Med (2018) 44:389–391
https://doi.org/10.1007/s00134-017-5022-7

LETTER

Positive end-expiratory pressure selection based on best respiratory system compliance or collapse/hyperdistension curves in patients with acute respiratory distress syndrome: lack of correlation with alveolar recruitment

Po-Lan Su[1], Wei-Chieh Lin[1], Yen-Fen Ko[3], Pei-Fang Su[4] and Chang-Wen Chen[1,2*]

Dear Editor,

Electrical impedance tomography (EIT) and the nitrogen washin/washout method (NWI-WO) for measuring recruitable lung volume (Vrec) provide new information for positive end-expiratory pressure (PEEP) selection in patients with acute respiratory distress syndrome (ARDS) [1, 2]. With EIT, the selected PEEP ($PEEP_{EIT}$) is the intersection between the collapse and hyperdistension (CH) curves [1], and a higher Vrec may deserve a higher PEEP [2]. We hypothesized that measurement of Vrec may help in our decision of PEEP and thus conducted a study comparing the Vrec with $PEEP_{EIT}$ or PEEP selection based on best respiratory system compliance ($PEEP_{best\ Crs}$) during decremental PEEP titration in ARDS patients. Our institutional review board (B-ER-103-317) approved this study and all patients provided informed consent. The preliminary result has been presented in abstract form at an international meeting [3].

Extended sigh was used for alveolar recruitment [4]. PEEP was sequentially increased from baseline to 15, 20, and 25 cm H_2O and then decreased from 25 cm H_2O to 20 and 15 cm H_2O twice. Each pressure was maintained for 30 s. Tidal volume (Vt) was decreased by 25% from baseline Vt during the incremental phase and increased by 25% during the decremental phase. Airway plateau pressure (P_{pl}) was determined at PEEP 25 cm H_2O ($PEEP_{25}$), 20 cm H_2O ($PEEP_{20}$) during the second recruitment maneuver and following end-expiratory lung volume (EELV) determination by NWI-WO at $PEEP_H$ 15 cm H_2O, $PEEP_I$ 11 cm H_2O, and $PEEP_L$ 7 cm H_2O (Fig. 1a). Cases with a difference between NWI-WO measurements of > 20 % were excluded [2]. Vrec was calculated as the difference between EELV at $PEEP_H$ and $PEEP_L$, after subtracting the minimal predicted increase in lung volume due to the difference in PEEP [2]. The method of Costa et al. [5] was used to determine the degree of CH during decremental PEEP titration. The intersection between CH curves and $PEEP_{EIT}$ were determined (Fig. 1b). Respiratory system compliance (Crs) was calculated as $Vt/(P_{pl}–PEEP)$.

Data are presented as mean ± SD. Spearman's rank correlation test and Kruskal–Wallis test was used for statistical analysis.

Twenty-three patients completed the study and five cases were excluded for difference between NWI-WO > 20 %. Eighteen patients left for analysis. Baseline Vt was 7.7 ± 0.7 mL/Kg PBW and baseline PEEP level was 12.3 ± 2.2 cm H_2O. PEEP levels were 24.8 ± 1.6 ($PEEP_{25}$), 20.3 ± 1.5 ($PEEP_{20}$), 15.7 ± 1.7 ($PEEP_H$), 11.8 ± 1.9

*Correspondence: cwchen@mail.ncku.edu.tw
[1] Medical Intensive Care Unit, Department of Internal Medicine, National Cheng Kung University Hospital, College of Medicine, National Cheng-Kung University, Tainan 70403, Taiwan
Full author information is available at the end of the article

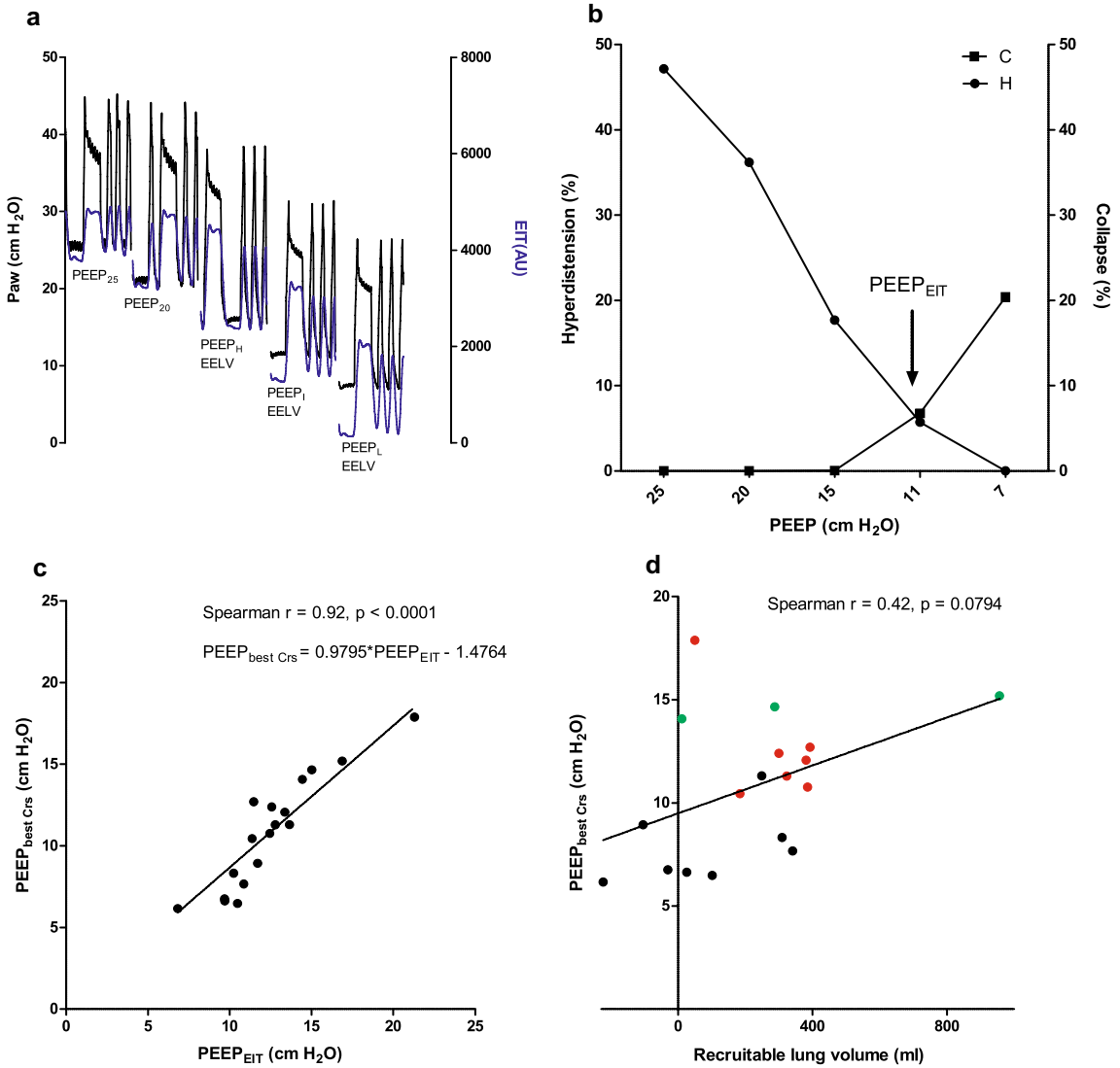

Fig. 1 **a** Extracted electrical impedance tomography (EIT), airway pressure (Paw) at five different levels of PEEP. End-expiratory lung volume (EELV) was determined by nitrogen washin/washout method at $PEEP_H$, $PEEP_I$, $PEEP_L$; plateau pressure was determined at 1 s following airway occlusion; AU: arbitrary unit. **b** Graphic demonstration of the crossover point between the collapse (C) and hyperdistension (H) curves and the corresponding PEEP level, designated as $PEEP_{EIT}$, in one patient. **c** Correlation analysis between PEEP selected using best respiratory system compliance ($PEEP_{best\ Crs}$) and $PEEP_{EIT}$. **d** Correlation analysis between $PEEP_{best\ Crs}$ and recruitable lung volume (Vrec). Green˙: $PEEP_H$, Red˙: $PEEP_I$, black˙: $PEEP_L$. In one patient PEEP levels of 30, 25, 21, 17, 13 cm H_2O were used and PEEP levels of 25, 20, 18,14, 10 cm H_2O were used in another patient because of potential concern about oxygen desaturation during lung volume measurement. Kruskal–Wallis test between Vrec and categorical $PEEP_{best\ Crs}$ or $PEEP_{EIT}$ (namely $PEEP_H$, $PEEP_I$, $PEEP_L$) was not significant

($PEEP_I$), and 8.0 ± 2.2 ($PEEP_L$) cm H_2O. Corresponding P_{pl} were 33.7 ± 2.7, 31.6 ± 3.4, 27.9 ± 3.0, 22.4 ± 2.1, and 18.7 ± 2.2 cm H_2O, and corresponding Vt were 210.7 ± 45.7, 342.0 ± 45.7, 456.7 ± 51.1, 454.5 ± 52.9, and 455.6 ± 53.1 mL. EELV was 1756 ± 390, 1494 ± 359.4, and 1201.0 ± 313.6 ml at $PEEP_H$, $PEEP_I$, and $PEEP_L$, respectively. Vrec between $PEEP_H$ and $PEEP_L$ was 218.6 ± 261.4 ml. CH at the intersection point averaged 6.9 ± 2.8 %. $PEEP_{best\ Crs}$ and $PEEP_{EIT}$ correlated well (Fig. 1c). Vrec did not correlate with $PEEP_{best\ Crs}$ or $PEEP_{EIT}$ (Fig. 1d).

Our findings suggest that PEEP selection based on $PEEP_{EIT}$ is justified. However, measured Vrec alone did not provide sufficient information for PEEP selection. However, the recruitment maneuver used in current study may not fully recruit the lung. This result may not be applied to a different recruitment protocol.

Electronic supplementary material
The online version of this article (https://doi.org/10.1007/s00134-017-5022-7) contains supplementary material, which is available to authorized users.

Author details
[1] Medical Intensive Care Unit, Department of Internal Medicine, National Cheng Kung University Hospital, College of Medicine, National Cheng-Kung University, Tainan 70403, Taiwan. [2] Medical Device Innovation Center, National Cheng Kung University, Tainan, Taiwan. [3] Institute of Biomedical Engineering, National Cheng Kung University, Tainan, Taiwan. [4] Department of Statistics, National Cheng Kung University, Tainan, Taiwan.

Acknowledgements
The authors would like to thank Medical Device Innovation Center, National Cheng Kung University, for providing EIT device.

Compliance with ethical standards

Conflicts of interest
The authors declare no competing interests.

Funding
This study was supported by Grants from Ministry of Science and Technology (106-2314-B-006-062) and NCKUH-10403009.

Accepted: 6 December 2017
Published online: 13 December 2017

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