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Impact of ultrasound settings on B-lines: an exploratory study in mechanically ventilated patients

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Introduction: The number of B-lines in lung ultrasound (LUS) impacts patients clinical management. This study aimed to demonstrate the US settings influence on the number of B-lines in patients under invasive mechanical ventilation (IMV).
Methods: Patients were prospectively recruited for LUS recordings including three breathing cycles with a motionless curvilinear probe on the thoracic region with more B-lines. Three clinicians were randomly enquired for the number of B-lines in baseline LUS and, blindly, after altering US settings for a total of 20 test recordings. The number of B-lines (mean ± standard deviation (SD)) across clinicians was compared between recordings.
Results: Twenty-nine patients (mean age 58 ± 18 years) admitted to critical care (mean SOFA score of 6.9 ± 3.3; mean delta SOFA of 2.4 ± 1.6) were under IMV due to neurological (n = 19) and respiratory illness (n = 10). They were evaluated at day 4 (± 2.6 days) of passive ventilation (plateau pressure 16 ± 3 mmHg; PEEP 6 ± 2 mmHg). On LUS day, patients had a fluid balance of 835 ± 1326 mL, an ultrasound-driven cardiac index of 3.1 ± 0.7 mL/min/m^2 and seven were under norepinephrine (0.5 ± 0.7 mcg/kg/min). Baseline recordings showed a mean number of 1.6 ± 1.2 B-lines from a total of 87 clinicians classifications. Clinicians classifications were grouped in grades (grade 0, one to two B-lines: 59; grade I, three to six B-lines: 25; grade II, above seven B-lines: 3). The classifications agreement level was strong (Kendall's coefficient of 0.77, $p < 0.002$). The probe frequency of 4 MHz (vs. 6/8 MHz), a gain of 90% (vs. 80%), and dynamic range of 84 dB (vs. 60 dB) increased the B-lines number by 0.4 ± 0.03 (Friedman pairwise comparison test, $p < 0.03$). US post-processing tools such as frame averaging, image enhancement or artifact, and speckle reduction decreased the B-lines number by 0.9 ± 0.24 ($p < 0.007$).
Conclusions: In this study, the US settings mildly influenced the number of B-lines but had a minor impact on clinical practice grades (± one B-line).

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Total signal intensity of ultrasound laboratory vertical artifacts: a semi-quantitative tool

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Introduction: Quantitative proposals to improve lung ultrasound (LUS) vertical artifacts (VA) interpretation using total signal intensity (I_{TOT}), are not widely available for clinical practice [1–3]. In this study, we aimed: (i) to develop a mathematical algorithm to extract I_{TOT} as a post-hoc LUS analysis, and (ii) to confirm I_{TOT} utility by conducting laboratory VA research using an in vitro model with different acoustic channels.
Methods: The I_{TOT} was extracted from static and conventional LUS imaging recorded from in vitro models after varying the amount of water content or the pores size of the phantom, in comparison with a control condition.
Results: The developed algorithm was able to calculate the I_{TOT} from all phantoms. Mean I_{TOT} showed statistically significantly different values across phantom categories.
Conclusions: We demonstrate that I_{TOT} may be able to differentiate the in vitro acoustic channels formed by increased water content from those with small size pores. However, the utility of this semi-quantitative tool in clinical practice or other LUS imaging data sets remains unclear.

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Sidestream-dark field videomicroscopy for the in vivo evaluation of the pulmonary alveoli and microcirculation in mechanically ventilated pigs

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Introduction: Under mechanical ventilation, the pulmonary microcirculation can be affected by the expansion or collapse of alveoli, resulting in a change in pulmonary vascular resistance. Sidestream-dark field (SDF) videomicroscopy has been used in animal models to assess pulmonary microcirculation in vivo. This study aimed to evaluate whether different mechanical ventilation settings could affect the alveolar size and pulmonary vessels in a porcine model.
Methods: This experimental study was conducted in four healthy pigs on mechanical ventilation under general anesthesia. The ventilation was initially set at a tidal volume (VT) of 8 mL/kg, PEEP 5 cmH_2O, and FiO_2 50%. Access to the thoracic cavity was obtained through surgical thoracotomy. The subpleural pulmonary microcirculation was assessed using SDF videomicroscopy at different ventilator settings: VT 8 mL/kg, PEEP 5 cmH_2O, FiO_2 50%; VT 12 mL/kg, PEEP 5 cmH_2O, FiO_2 50%; VT 8 mL/kg, PEEP 12 cmH_2O, FiO_2 50%; VT 8 mL/kg, PEEP 5 cmH_2O, FiO_2 100%. We calculated the diameter of the alveoli and extra-alveolar microvessels.
Results: Comparing VT 8 mL/kg and VT 12 mL/kg, we observed a significant increase in alveolar diameter (89 [70.6–114.7] µm vs. 94.6 [78.3–115] µm, $p = 0.04$) and a significant decrease in vessels diameter (10.4 [8.6–12.7] µm vs. 9.2 [7.6–11.2] µm, $p < 0.01$). We did not observe a significant difference in alveolar and vessels diameters after changing the PEEP from 5 to 12 cmH_2O. Increasing the FiO_2 from 50 to 100%, the alveolar diameter significantly raised (86.7 [69.6–112.6] µm vs. 94 [72.7–122.5] µm, $p = 0.03$) as well as the vessels diameter (10.4 [8.5–12.5] µm vs. 12.2 [10.3–14.7] µm, $p < 0.01$). Subpleural pulmonary microcirculation is shown in the Figure.
Conclusions: Mechanical ventilation affects alveolar and pulmonary vessel size. SDF microscopy represents a valid tool to assess the subpleural pulmonary microcirculation in vivo in porcine models.

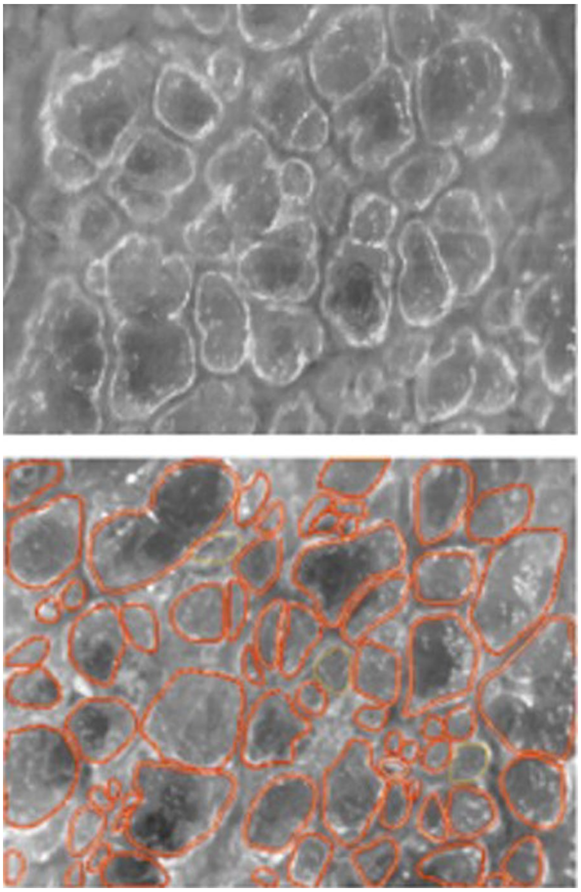

Figure (abstract P128) Subpleural pulmonary microcirculation.

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Augmenting simulated pressure support ventilation data using adversarial learning for asynchrony detection

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Introduction: In this study, we introduce a novel approach for generating synthetic ventilation waveforms with labels, based on generative adversarial networks (GANs). These waveforms serve as training data for machine-learning algorithms to improve detection and classification of patient-ventilator asynchrony (PVA), an adverse event during mechanical ventilation [1, 2].

Methods: GANs refine simulations of patient-ventilator interactions incorporating ventilator-specific and patient-specific factors while employing adversarial learning and self-regularization to preserve the labeling of the simulations. We evaluated the use of the generated data for training PVA detection and classification methods, comparing it to the original simulated data [3].

Results: The use of generated data translated into enhanced PVA detection and classification. Notably, the detection method trained on generated data showed improved accuracy in locating the patients' respiration which resulted in an increased classification performance when validated with an independent clinical dataset from a different hospital (Table). Although the detection method trained on generated data excelled across various PVAs, detecting "ineffective effort" presented challenges due to inherent noise in real clinical data.

Conclusions: This study underscores the potential of GANs in improving PVA detection and classification, contributing to improved quality of mechanical ventilation. Moreover, the proposed approach could be translated to other areas where labeled data are scarce.

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Table (abstract P129) Detection result for simulated and generated

Metric	Simulated data	Generated data
Recall	94.8%	91.4%
Precision	98.5%	99.3%
RMSE In	0.099 s	0.085 s
RMSE Ex	0.097 s	0.073 s

RMSE (Root mean squared error).

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Examining social determinants of care in ventilated patients in critical care

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Introduction: This study investigates non clinical factors affecting adherence to clinical turning protocols in mechanically ventilated patients; factors we call social determinants of care (SDoC). Social determinants of health are known contributors to health outcomes, however the impact of SDoC on clinical care has yet to be investigated. Utilizing the MIMIC-IV database, we analyzed a cohort of 8919 patients to identify disparities in care related to social factors.

Methods: The study included all patients who underwent invasive mechanical ventilation (IMV), excluding cases with missing weight data or weights outside the 10–250 kg range. Frequency of turning documentations per day were evaluated and compared using Kolmogorov–Smirnov tests and predictive models such as ridge regression, to assess adherence to turning protocols during IMV. These methods were cross-validated and included varying degrees of artificially injected noise for robustness.

Results: The patient cohort mean age was 63.5 years, with 58% males, white ethnicity (61.2%), and 88.8% reported English as