Asynchrony Injures Lung and Diaphragm in Acute Respiratory Distress Syndrome.

Haruka Hashimoto, M.D.; Takeshi Yoshida, M.D., Ph.D.; Andi Muhammad Fadlillah Firstiogusran, M.D.; Hiroki Taenaka, M.D.; Yukiko Koyama, M.D., Ph.D.; Akinori Uchiyama, M.D., Ph.D.; Yuji Fujino, M.D., Ph.D.

Abstract

Rationale: Spontaneous breathing is preserved during mechanical ventilation in patients with acute respiratory distress syndrome (ARDS) since it provides numerous benefits from a physiological point of view. Accumulating evidence indicates that spontaneous breathing added to mechanical ventilation may worsen lung injury by increasing tidal volume (V_T) and/or maldistribution of lung stress in ARDS. Spontaneous breathing often causes patient-ventilator asynchrony, but its impacts on lung and diaphragm is still unknown.

Objectives: To investigate the impact of each asynchrony *(i.e.* breath stack, reverse trigger) on lung and diaphragm.

Methods: Lung injury was induced by surfactant depletion. Lung-injured rabbits were randomized to three groups as follows: 1) assist control group (group AC, n=6), 2) breath stack group (group BS, n=6), and 3) reverse trigger group (group RT, n=6). Animals were ventilated with volume-controlled mode with V_T of 6-8ml/kg and positive end-expiratory pressure (PEEP) of 2 cmH_2O for 4 hours. Each type of asynchrony was reproduced by stimulating bilateral phrenic nerves. Lung injury (histology. bronchoalveolar fluid), diaphragm function (transdiaphragmatic pressure-frequency curve at 10,30,50,80,100 Hz) and diaphragm injury (histology) were assessed.

Measurements and main results: BS caused highest peak Δ transpulmonary pressure (ΔP_L) and largest V_T (Δ P_L: 23.3±3.3 *vs*.10.4±2.5 *vs*. 10.5±4.8 cm H_2O in BS, AC, RT; V_T: 10.5±1.9 *vs*7.3±0.4 *vs*. 7.0±0.5 ml/kg in BS, AC, RT), resulting in worst oxygenation (154±195 *vs*.464±32 *vs*. 390±178 mmHg in BS, AC, RT), worst dynamic lung compliance (1.67±0.5 *vs*.2.66±0.5 *vs*. 2.90±1.1 ml/cm H_2O in BS, AC, RT), highest concentration of total protein (493±338 *vs*.90.2±71 *vs*. 165±157 mg/dL in BS, AC, RT) and IL-6 (2.93±2.4 *vs*.0.85±0.3 *vs*. 1.27±1.64 pg/mL in BS, AC, RT) in bronchoalveolar fluid. RT maintained tidal volume of 6-8 ml/kg throughout the protocol and did not worsen lung injury (*vs*. AC). Both BS and RT (*vs*. AC) resulted in less diaphragm force generation at 50,80,100 HZ (***Figure A***). Diaphragm injury score was significantly higher in BS and RT than in AC (65.1±10 *vs*.25.7±8.0 *vs*. 53.5±19 %in BS, AC, RT). The cross-sectional area (CSA) of type 1 and type 2 was largest in BS while RT resulted in significantly larger CSA of type 2 than AC. Representative images of histology are shown in ***Figure B***.

Conclusions: Breath stack injured lung and diaphragm in an animal model of lung injury and reverse trigger injured diaphragm.

Figure A

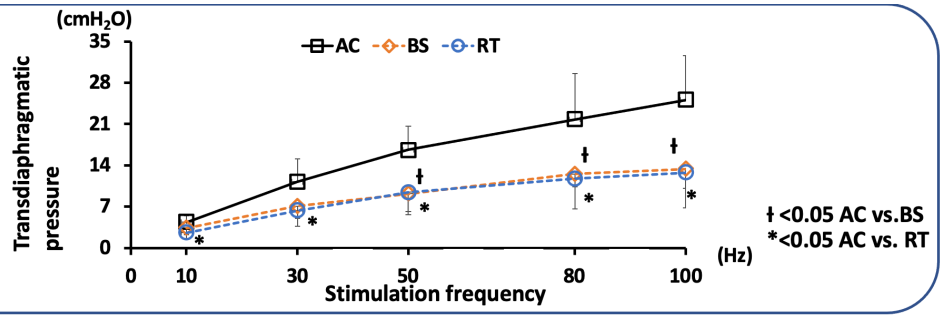

Figure B