Methods For Lung-Protective Mechanical Ventilation

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Technology description

Background:
The terminal airspaces of the lungs, the alveoli, are lined with a thin liquid layer. Thus there is an air-liquid interface in the lungs that has an associated surface tension. To reduce the surface tension, alveolar type II epithelial cells release surfactant—an aggregate of phospholipids and proteins—into the liquid lining layer. The surfactant adsorbs to and reduces surface tension at the air-liquid interface. By lowering surface tension, surfactant reduces the pressure required to keep the lungs inflated and reduces the work of breathing.
Acute lung injury (ALI) and its more severe form, acute respiratory distress syndrome (ARDS), can result from a variety of initial insults. In both forms of lung injury, inflammation is present in the lungs. With inflammation, pulmonary vascular permeability increases and liquid leaks out of the blood vessels. The liquid carries plasma proteins with it. When enough liquid escapes from the vessels, liquid begins to enter the alveoli, a condition known as alveolar edema. From the onset of edema, the additional liquid in the airspace effectively thickens the alveolar-capillary membrane across which oxygen and carbon dioxide must be exchanged, making respiration difficult. Further, in ALI/ARDS, lung compliance is reduced, which makes breathing difficult.
Summary:
Methods are provided for protecting against ventilation-induced lung injury both directly, by lowering surface tension, and indirectly, by promoting equitable liquid distribution in pulmonary alveolar edema, in which liquid- and air-filled alveoli are normally interspersed. Since a pressure barrier is responsible for trapping liquid in discrete edematous alveoli and the magnitude of the barrier is proportional to surface tension at the air-liquid interface, the present invention provides various methods for promoting equitable redistribution of edema liquid amongst alveoli to help protect the lung during ventilation, including:
- Use of an additive that lowers surface tension
- Use of active, accelerated deflation during mechanical ventilation
- High frequency (>50 Hz) vibration of the lung

In the present invention, a surface tension lowering agent is added to alveolar edema liquid to (i) directly lessen over-distension injury of air-filled alveoli located adjacent to liquid-filled alveoli, and (ii) promote equitable edema liquid redistribution among alveoli. Such surface tension lowering agents may include certain rhodamine dyes. Also, an active, accelerated deflation method is applied during

mechanical ventilation of the edematous lung to promote equitable edema liquid redistribution between alveoli. The present invention includes an apparatus for generating such pressure waveforms. High frequency vibration of, or step or impulse force application to, the edematous lung promotes equitable edema liquid redistribution among alveoli. Such vibrations, or step or impulse forces, may be applied by various means.

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