The educational video

# The Open Lung Concept

presented by

Dr S. Böhm, Medical Advisor in collaboration with Prof. Dr Dr B. Lachmann, Dr M. Amato, Dr F. Suárez Sipmann and Dr L. Tokics

## **Expert** opinions



"The only way to really convince experienced physicians about the open lung concept is to give them a chance to try it for themselves ...seeing is believing."

Prof. Dr Dr B. Lachmann

"I believe that in the future every patient in the ICU must have some kind of device or monitor giving us information about the

situation of the lung and if the pressures we are applying are enough to keep the lung open...We have to think about the lung as we think about the heart today." *Dr M. Amato* 





"Atelectasis is seen in most patients during anaesthesia... In most patients about 2–10% of the cross-sectional area of the lung, as seen on the CT scan, becomes atelectatic. And this does not seem very much, but it has a profound effect on blood oxygenation, because about 5% of the volume of the lung when atelectatic represents about 15–20% of the lung in the aerated condition." Dr 1. Tokics "So we take the risk of increasing the pressures above the threshold set by the Consensus Conference for a short period of time to obtain the benefit of a maximum lung recruitment, and after achieving this goal we strive to find the lowest possible pressure at which we can ventilate the patient. This final pressure at the steady state is usually lower than the limit set by the Consensus Conference." *Dr F. Suárez Sipmann* 





"Ideally, we would like to ventilate the lungs in an open condition, but at the lowest possible pressure. We need to avoid alveolar colapse. This means that we must first open any collapsed alveoli and then balance the airway pressures, in order to keep the lungs open." *Dr S. Böhm* 

## The problem



SCANNING ELECTRON MICROGRAPH OF A CROSS-SECTION THROUGH AN ALVEOLUS To ensure optimal gas exchange, the delicate structure and function of the alveoli must be protected.



CT SCAN OF HEALTHY LUNGS DURING GENERAL ANAESTHESIA During general anesthesia even healthy lungs will develop regions of alveolar collapse.

## The underlying mechanisms



### THE SURFACE OF THE LUNG

Through a thoracoscope the effects of anesthesia and ventilation can be observed directly. Several atelectatic areas have developed in the dependent parts of the lung. Around the edges of the atelectatic areas are regions where the alveoli open and close with each breath.



SHEAR FORCES START A VICIOUS CIRCLE OF EVENTS The continuous opening and closing of alveoli in the transitional zone between open and collapsed regions of the lung generates shear forces. These forces between open and collapsed alveoli are believed to be the underlying cause of damage.



EVERYDAY EXAMPLES ILLUSTRATE BASIC PRINCIPLES Anyone who has struggled to inflate a new balloon knows how hard it is to blow the first air into it, but that once you have managed to do so it is much easier to inflate the rest of the balloon. This is rather similar to the situation when opening collapsed alveoli.



## HOW TO AVOID THE PROBLEM

Stephan Böhm uses a simple model to explain how to avoid the problem of alveolar collapse and reopening which causes extensive changes in alveolar surface area and leads to surfactant dysfunction during artificial ventilation.

# The open lung concept



Vate



As airway pressures are increased there is initially no change in lung volume. Suddenly, there is a rapid increase in volume. The opening pressure has been found.

More and more alveoli open as the pressure is increased. At the point where further increments in pressure result in no additional increase in volume, the lung is maximally open. The alveoli will become overdistended if the pressure is raised further.



Volume Crossing Pressure Pressure



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## FIND THE CLOSING PRESSURE

As the airway pressures are reduced, the lung volume remains high until the closing pressure, indicated by a sudden and dramatic drop in volume, is reached. The lung starts to collapse.

#### **REOPEN THE LUNG**

Once parts of the lung have collapsed, the only way of reopening these areas is to once more exceed the opening pressure for a short period of time.

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#### KEEP THE LUNG OPEN

To maintain the open state of the alveoli, the airway pressures are reduced to a point that is safely above the closing pressure.

# **Case histories**



The film contains two authentic case histories. Suárez Sipmann guides us through the clinical application of the open



lung concept, step by step. The patient data is recorded on a graph, a copy of which is found on the facing page.













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