Alveolar recruitment: physiological basis and strategies, tools and application
Faculty members of the VUMC University Hospital in Amsterdam were inspired to start their own series of post-graduate workshop courses after attending a session at the Uppsala University Hospital last year. Within a few months, they organized their first educational workshop in the series. Critical Care News met the educational faculty and lab participants after a comprehensive workshop session.

**Alveolar recruitment: physiological basis and strategies, tools and application**

The Pathophysiology of ARDS and Consequences for Treatment was the subject of the lecture held by Professor Johan Groeneveld MD, PhD. After thoroughly detailing ARDS definition and pathogenesis from early to late stages, Professor Groeneveld summarized that the pathophysiology of ARDS depends on the underlying cause, whether direct or indirect, and that ARDS is a dynamic process dependent on injury, repair, effect of regional blood flow and ventilation. He also underlined the need for a simple, reproducible pathophysiological quantitative and specific test for ARDS.

Dr Jan Jaap Spijkstra presented the next topic, Ventilator Induced Lung Injury, with particular reference to volutrauma and shear stress. He highlighted a review of the literature, with the growing insight that what was previously referred to as barotrauma should be defined as volutrauma. He underlined that the uneven distribution of the lung lesions in ARDS may easily lead to regional over-inflation and additional lung damage. The causes of shear stress were explained, and the role of shear stress in the development of VILI was discussed. The ways in which volutrauma and shear stress may lead to biotrauma were outlined, and subsequently the role of biotrauma and the systemic progression to sepsis and multi-organ failure.

Dr Dick G Markhorst lectured on the topic of PEEP. He underlined the clinical benefit and role of PEEP in more uniform distribution, as well as alveolar PV relationship and vertical pressure gradients. The physiological conditions of alveolar interdependence and the effects of repetitive opening and closing, end-expiratory atelectasis and anti-inspiratory over-distention were outlined in detail. Dr Markhorst also presented the significance of pulmonary perfusion and the effects of PEEP on hemodynamic parameters, as well as the risks of excessive PEEP. He concluded his lecture with a comprehensive literature review, focusing on what has been reported as the optimal PEEP in recent years, and the ARDSnet data. He cautioned that a generic level of PEEP is not the objective; it is necessary to address the level of PEEP required by each individual patient dependent upon lung injury severity, in order to reach therapeutic goals supported by the current best evidence.

Alveolar Recruitment Strategies and Comparison of Techniques was presented in a lecture by Dr Hagen Biermann, with an overview of key principles, methods, experimental studies and clinical trials, with special emphasis on efficacy and hazards.

The aspects of prone position, adequate PEEP and tidal volumes, lowest acceptable FiO₂ and spontaneous efforts were emphasized. He also posed the question of whether the lung should always be opened, with respect to primary and secondary ARDS. Recruitment maneuver effectiveness, lavage in ARDS, oleic acid injury and a pneumonia model were discussed, with reference to an intercomparison of three models, with three levels of post-recruitment PEEP in regard to sustained inflation, incremental PEEP and high-level pressure control. Dr Biermann concluded that pressure-controlled ventilation should be preferred to...
sustained inflation, and that the use of hemodynamic monitoring is essential during recruitment maneuvers. He also stressed the importance of repeating recruitment after patient disconnections, position changes or deterioration of mechanics and/or PaO₂.

Dr. Jan Jaap Spijkstra followed with the topic of Lung Protective Ventilation, with reference to ventilator settings, tidal volumes and PEEP currently used in ICU departments all over the world. He presented an in-depth review of low-volume ventilation used in clinical trials of lung protective mechanical ventilation in ALI patients. The contradictory results so far were discussed, as well as the conclusion that low tidal volumes are beneficial for patients, not only lowering mortality and morbidity, but also reducing the extent of biotrauma. Trials with different levels of PEEP were also reviewed, with emphasis on the disappointing results and the possible explanations for them.

Dr. Hagen Biermann also gave the final lecture, on the subject of Lung Recruitment with the Open Lung Tool. He outlined the mechanisms of collapse, lung weight and height, gas adsorption, and the relationship between chest wall and abdominal pressures. The tool parameters were illustrated with graphical breath-to-breath observation of end inspiratory, PEEP and inspired tidal volumes. Changes in lung mechanics during a recruitment maneuver were illustrated with real-time monitoring, as well as graphic visualization of measured and calculated values. The function for analysis of opening and closing airway pressures was reviewed, and an example of a step-by-step recruitment maneuver was given.

References


11) Ranieri VM, Quinta F, Suter PM, Slutsky AS. Mechanical ventilation as a mediator of multisystem organ failure in acute respiratory distress syndrome. JAMA 2000; 284:43-44.


In the physiology laboratory after a lavage procedure, workshop participants had the opportunity to initiate the recruitment maneuver in a stepwise manner: determining the critical opening and closing pressures while monitoring dynamic compliance and VT$_{CO_2}$ levels. Re-recruitment was then initiated by setting EIP to deliver a tidal volume of 7 ml/kg, and ventilation was maintained by setting a PEEP of 2 cm/H$_2$O above the critical closing pressure.

Critical Care News got impressions of the course from two groups of participants.

**Why are you interested in lung recruitment?**

**WJ Engelbrecht, anestesiologist and ICU fellow:** We are dealing with critically ill patients, from the OR to the ICU, so we are interested in lung-protective strategies. The subjects and the sessions today were very good.

**Would you be able to do a recruitment maneuver on patients after the session today?**

**JE Steenhuizen, anesthesiology fellow:** Yes.

In the past, we have mostly used PEEP titration and pressure gradients, or inspiratory hold. This concept and tool is quite new and I think there are advantages to it.

**What about in the PICU, are you interested in applying the recruitment steps you learned today?**

**DAH de Gast-Bakker, pediatrician, PICU fellow:** We have been recruiting by means of inspiratory hold, depending on the patient and disease categories. Some children just don’t have enough lung volume, so we have mixed problems. I think we should try the stepwise recruitment protocol and maneuvers we learned about today. We always need to think about being able to change what we are doing.
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What aspects of the workshop were of most value to you?

RJ Trof and TMD Nguyen, ICU fellows: The theoretical part was good. It is important to know the background to what we are applying in practice. It is also valuable to see how it works in practice.

We are already doing recruitment maneuvers with end tidal CO₂. We are starting to learn this in the unit, and are already a little familiar with it.

What is your opinion of the stepwise recruitment maneuver, in comparison to others?

EWJ Schubert, ICU fellow: The good thing about the stepwise procedure is that you get parameters to measure what you are doing, in contrast to other types of recruitment. Using the Open Lung Tool, you can see what you are achieving and get more patient information. This approach seems superior.

It may take more time in some patients, especially unstable cases where there might be hypotension. However, this procedure clearly has fewer disadvantages than other procedures.