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Lung recruitment

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What is lung recruitment?

Lung recruitment (LR) is the use of an increased transient sustained transpulmonary pressure, in order to open up (recruit) previously collapsed alveoli and improve oxygenation.[1]

Where did the concept of lung recruitment come from?

The concept of LR comes up mainly in discussions around patients with acute respiratory distress syndrome (ARDS), where it has been shown that there is heterogenicity in the alveoli filling, with some regions being collapsed therefore not filling and not taking part in tidal volume ventilation, whilst other areas are open, and some are even over-distended.[2] LR has shown both beneficial and negative effects, thereby making patient selection as well as timing of recruitment very important.[3]

Recruitment manoeuvres have been shown to be beneficial to prevent derecruitment during anaesthesia,[4] during induction of anaesthesia there is a high incidence of a decrease in functional residual capacity,[5] the percentage of lung collapse is variable but may go as high as 25% in patients who are susceptible. Table I shows a list of patients that may benefit from LR after anaesthesia-induced atelectasis.[5]

Table I: Patients who benefit most from recruitment manoeuvres[5]

Anaesthesia-induced atelectasis in
Children under 6
Patients under 30 years
Obese patients
Pregnant patients in the third trimester
Laparoscopic surgery
Anaesthesia in Trendelenburg position
Thoracic surgery
Cardiac surgery
Abdominal surgery

How is lung recruitment performed?

There are a few manoeuvres that can be applied in different ventilation modes that have been described; we will go into how to do them shortly. Preceding these manoeuvres, it is advised that the patient should always be sedated or under general anaesthesia; the use of muscle relaxant is not compulsory;[6] and lastly, the patient should be haemodynamically stable. It is also important to monitor for changes in haemodynamics and oxygen saturations. An initial and transient fall in one or both may occur and if the decrease persists, this should prompt the clinician to stop the manoeuvre.[7]

Recruitment manoeuvres could previously be delivered in control modes, pressure/volume control, as well as in the spontaneously breathing patient.[6] However, of late, pressure control mode and gradual increases in positive end-expiratory pressure (PEEP) seem to be preferred.[5]

In spontaneously breathing patients, continuous positive airway pressure (CPAP) of 40 cm H_2O for 40 seconds was applied, or CPAP of 35–45 cm H_2O for 30 seconds.[3,8] On volume control mode, a manoeuvre called an extended sigh (e-sigh) manoeuvre was applied, where the tidal volumes were reduced slowly from 8 to 2 ml/kg, and the PEEP increased from 10–25 cm H_2O, in a gradual manner. Once a PEEP of 25 cm H_2O and tidal volume of 2 ml/kg has been reached, a CPAP level of 30 cm H_2O is applied for 30 seconds; after this period, the opposite is done till one gets to baseline settings.[9]

On a pressure control mode, one may gradually increase the sustained inflation pressure to 40 cm H_2O for 7–8 seconds[10] or with the driving pressure set at 15 cm H_2O, a gradual increase in PEEP is applied until a peak pressure of 40 cm H_2O. This is then maintained for 5–10 breaths and then gradually decreased until ideal PEEP.[11,12] In order to avoid derecruitment after a manoeuvre, an appropriate PEEP level should be set.[6]

How do we know the lung recruitment manoeuvre has worked?

There are direct and indirect methods of assessing if the chosen lung recruitment manoeuvre has worked. Since more alveoli are taking part in tidal volume ventilation, the expected result is an improvement in the patient's gaseous exchange and lung mechanics.[13] The three markers that have been used to indirectly measure recruitment are oxygenation, compliance and the stress index, therefore by simply looking at an arterial blood gas and the ventilator, one will be able to judge the success of the recruitment manoeuvre,[6] but positive changes in these

three parameters are not always only due to lung recruitment strategies,[13] and are therefore not always reliable markers. For example, improved oxygenation may be due to a fall in cardiac output and thereby a fall in the intrapulmonary shunt[13] and not the recruitment of collapsed alveoli.

The direct methods that can be utilised are computed tomography (CT) scan and pressure-volume (PV) curves (reference techniques). CT scan provides images of lung aeration and recruitment is measured as the amount of non-aerated tissue at certain pressures that reinflate at higher pressures.[14] But this cannot be done routinely, unlike PV curves which are much easier to do, and these are plotted by looking at end-expiratory lung volumes at different PEEP values.[15]

Other direct measurement tools that have gained popularity are electrical impedance, ultrasound, and the recruitment-to-inflation ratio.[13] Although electrical impedance has gained popularity, it is not as easily accessible as the ultrasound technique.[13] When using the ultrasound, four regions are examined on the left and right side of the chest, namely, the upper and lower anterior regions, then the lateral and posterior regions – images may be saved for reference. These regions are then described as either normal aeration (lung sliding present with A lines or less than 2 B lines), moderate loss of aeration (multiple B lines that are well defined), severe loss of aeration (multiple B lines that are coalescent) or lastly, lung consolidation.[16] Each region is re-examined on a PEEP of 0, then PEEP of 15 cm H_2O. After examining the changes in each region, an ultrasound reaeration score is then calculated. This score is correlated with PEEP-induced lung recruitment and can be quantified with PV curves.[16]

The pros and cons of lung recruitment

Recruitment manoeuvres have shown benefits such as improved oxygenation, a decrease in the fraction of inspired oxygen needed intraoperatively, and decreased postoperative pulmonary complications.[17]Although there is no ideal manoeuvre, it has been noted that some manoeuvres can cause more haemodynamic compromise than others, in particular those using high inflation pressures.[3] Furthermore, lung recruitment has the potential to cause barotrauma/volutrauma[18] and it is absolutely contraindicated in some cases, such as in patients with brain injuries.[5] Table II shows other contraindications to recruitment manoeuvres.[5]

Table II: Contraindications for recruitment manoeuvres[5]

Patients with severe uncontrolled hypotension
Head trauma
Intracranial hypertension
Open eye surgery
Undrained haemothorax
Bronchospasm
Pulmonary emphysema
Lung bullae

Conclusion

We often encounter patients who have hypoxaemia intraoperatively in anaesthesia, hence LR can be of use in the theatre setting, but one needs to be cognisant of a few things, such as a consolidated lung cannot be recruited, a patient already on a high PEEP level may not benefit from further recruitment, and over-recruitment will result in over-distention which will worsen the patient's already poor state.[6] Therefore, patient selection remains a key factor in LR. Despite the controversies surrounding the topic, it still remains an important tool to use in the appropriate setting.

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