Smart tools in lung protective ventilation

A variety of advanced technologies are now available that can help combat post-operative pulmonary complications. This article provides an insight into the latest intelligent solutions and how they can help to improve outcomes.

Every year, more than 230 million major surgical procedures requiring general or regional anaesthesia are undertaken worldwide.[1] According to the LAS VEGAS researchers' group, 10% of patients who underwent general anaesthesia and received mechanical ventilation, will develop post-operative pulmonary complications (PPCs).[2] PPCs are defined as unplanned supplementary oxygen, new or prolonged invasive ventilation, respiratory failure, acute respiratory distress syndrome (ARDS), and pneumonia.

Rather than providing treatments once PPCs occur, a better strategy is to focus on prevention.[3] This requires intelligent technology that can validate and interrogate data at the bedside, providing clinicians with a greater insight into patient health. Mindray's range of anaesthesia products and solutions, coming to the NHS framework this March, are equipped with these smart tools to support effective lung protective ventilation.

Lung protective ventilation is widely recognised as an effective strategy to keep the alveoli open while avoiding barotrauma. Commonly used strategies include optimal positive end-expiratory pressure (PEEP) titration, low-tidal volume, and lung recruitment manoeuvres.[4]

Optimal PEEP for individualised patient care

The use of neuromuscular blocking drugs in anaesthesia can lead to a considerable drop in the lung's Functional Residual Capacity (FRC) of between 15-20%.[5] Decrease of FRC frequently causes atelectasis, a condition which can be prevented by administering PEEP at the optimal level for each individual patient, with just 10cm H2O of PEEP showing drastic improvement in collapsed lungs.[6]

However, evidence suggests that different PEEP settings are required for individual patient characteristics, such as chest wall shape, abdominal content, positioning, and pleural pressures.[7] The optimal PEEP is the PEEP setting that leads to the lowest intrapulmonary shunt without compromising cardiac output.[8] There are several titration methods commonly used to find the optimal PEEP, including: pulmonary compliance directed methods, Vds/Vt guided technique based on imaging, and transpulmonary pressure directed procedures.[9]

Transpulmonary pressure is the actual pressure distending the lung, which means the difference between the airway pressure and the pleural pressure (Paw - Ppl). By keeping a positive end expiratory transpulmonary pressure, the transpulmonary pressure PEEP titration method allows clinicians to assure the adequate PEEP without alveolar collapse and over-distention.

Transpulmonary pressure monitoring on the A9/A8

Mindray's A9/A8 anaesthesia systems can provide an auxiliary pressure channel, allowing real-time measurement of the oesophageal pressure through a balloon catheter. The transpulmonary pressure can be accurately calculated by oesophageal pressure and thus help efficiently guide the optimal PEEP setting. Waveforms and parameters such as end-inspiratory transpulmonary pressure, end-expiratory transpulmonary pressure, and transpulmonary driving pressure are shown simultaneously, to help optimise ventilation settings, allowing for more confident clinical decision-making.

Lower tidal volume

Experimental and observational studies show that high tidal volumes may cause alveolar distension and ventilator-associated lung injury (VALI). The IMPROVED clinical trial suggested that protective lung ventilation and non-protective ventilation have different tidal volume settings of 6-8ml/kg versus 10-12 ml/kg. In retrospect, the lung protective ventilation group has a lower risk of PPCs with lower levels of ventilation support required and shorter hospital stays after surgery.[10]

Vt/IBW Indicator on the A9/A8

The Mindray A9/A8 anaesthesia system can set Vt/IBW to its volume control mode to guide the default tidal volume based on a patient's ideal body weight. Additionally, when the clinician adjusts the tidal volume, a clear Vt/IBW indicator is displayed simultaneously to guide lower tidal volume strategy.

Recruitment manoeuvres

A recruitment manoeuvre aims to re-expand collapsed alveoli and augment the exchange surface at the alveoli-capillary membrane, to avoid intra-and postoperative lung complications.[11] A wide variety of recruitment manoeuvres have been reported and used in practice, including sustained inflation, stepwise increase of tidal volume ventilation, incremental PEEP procedure, etc. The best recruitment manoeuvre technique may vary according to the specific patients and circumstances.[12]

The sustained inflation technique is frequently used during surgery, in which a continuous pressure of 40cm H2O is applied to the airway for 30-60 seconds. This manoeuvre is often performed by "bag squeezing" using the airway pressure-limiting (APL) valve of the anaesthesia machine. However, sometimes the airway pressure can be difficult to control manually and is instead adjusted step-by-step. The stepwise PEEP procedure is the process of increasing PEEP step-by-step (incremental), sustaining several breath cycles in each step, then decreasing PEEP step-by-step (decremental) to a normal level. During the decremental phase, optimal PEEP can be titrated by monitoring the best pulmonary oxygenation or compliance.

Recruitment Pro Tool in the A9/A8

Mindray's A9, A8 and WATO EX65 Pro anaesthesia systems are equipped with powerful lung recruitment tools. There are two commonly used recruitment manoeuvres on Mindray anaesthesia machines: the sustained inflation and the stepwise PEEP manoeuvre, allowing clinicians to choose the most suitable tool for their patients. Both manoeuvres can be started and stopped with one key, without adjusting several control parameters or squeezing the bag manually.

In the one-step recruitment tool, the sustained pressure and duration can be easily customised.

Additionally, the recruitment can be repeated automatically at a pre-set interval, such as 30 minutes, allowing more effective recruitment during long-term surgery.

In the multi-step recruitment tool, up to five procedures can be customised and saved to make the lung recruitment process quick and easy. Information is displayed on the [Recruitment] menu to help evaluate the effect of recruitment and guide the titration of optimal PEEP, including real-time values and trends of tidal volume, compliance, pressure, and loops.

HFNC

Another useful tool to deliver lung protective ventilation and combat PPCs, is the high flow nasal cannula (HFNC). High-flow nasal cannula (HFNC) is a humidified gas or oxygen delivery system that allows inspired oxygen (FIO2) to be delivered at very high flow rates. A recent study suggests a potential benefit of HFNC on alveolar recruitment in patients with hypoxaemic hypoxemic acute respiratory failure (ARF), compared with non-invasive ventilation (NIV), which while still beneficial for alveolar recruitment, may contribute to overdistension and subsequent PPCs.[13] HFNC has been shown to prolong the safe apnoea window, reduce instances of hypoxaemia and allows clinicians more time to manage patients with difficult or compromised airways.[14] The Mindray A9 anaesthesia workstation has a HFNC system integrated into the machine itself, offering a faster and more efficient emergency response by removing the potential delays and hazards of sourcing and using a separate device.

Conclusion

Clinicians have an array of techniques at their disposal to deliver truly effective lung protective ventilation, all of which can supported by smart tools to help improve patient outcomes and combat PPCs. These tools can help ensure more timely and decisive decision making in anaesthesia, with solutions like transpulmonary pressure monitoring on the A9/8 offering clinicians a vital way to validate and act on information immediately and with greater confidence.

Mindray's range of anaesthesia devices and the smart tools they offer comes to the NHS framework in March, ready to support clinicians in delivering the best outcomes for their patients.

References

References for this article are available at: www.clinicalservicesjournal.com.

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