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Optimizing perioperative mechanical ventilation as a key quality improvement target

Otimização da ventilação mecânica perioperatória como alvo fundamental para melhora da qualidade

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BACKGROUND

The occurrence of postoperative pulmonary complications is strongly associated with increased hospital mortality and prolonged postoperative hospital stay.[1,2] Postoperative pulmonary complications could, at least in part be prevented by using so-called lung protective mechanical ventilation strategies, which may include use of low tidal volume (V_T), positive end-expiratory pressure (PEEP) and low oxygen fractions (FiO_2).[3]

TIDAL VOLUMES

Anesthesiologists commonly used ventilation strategies with high V_T during general anesthesia for surgery because this strategy has the potential to re-open those lung regions that collapse at end-expiration. This could reduce the need for high FiO_2, as it reduces ventilation-perfusion mismatch, and as such prevent oxygen toxicity.[4] Moreover, use of high V_T was considered to be safe since intraoperative ventilation usually only last hours. Animal research, though, convincingly demonstrated that high V_T ventilation in animals with healthy lungs has a strong potential to cause lung injury, even when short-lasting.[3] Furthermore, one randomized controlled trial (RCT) comparing ventilation with low V_T (6mL/kg predicted body weight - PBW) with ventilation with high V_T (10mL/kg PBW) in critically ill patients with uninjured lungs confirmed that ventilation with high V_T induces lung injury,[5] and metaanalyses of observational studies showed an association between V_T size and duration of ventilation.[6,7] Several small clinical trials of intraoperative ventilation further improved our understanding of the harmful effects of high V_T,[3] and recently three randomized controlled trials convincingly showed that a ventilation strategy that uses low V_T prevents development of postoperative pulmonary complications.[8-10] Low V_T ventilation is becoming standard of care in the operation room, as suggested by a report on intraoperative ventilation practices in a large number of university hospitals in the USA showing that V_T nearly halved over the last decade, to 7 to 8mL/kg PBW.[11] It is possible, but certainly not proven, that a further reduction of V_T during intraoperative ventilation could even further reduce development of postoperative pulmonary complications.

POSITIVE END-EXPIRATORY PRESSURE

Induction of anesthesia, especially when using high FiO_2, has the potential to induce atelectasis. Ventilation with low V_T could further increase alveolar instability.[12] PEEP has the potential to open collapsed lung regions, and could maintain the alveoli open during the whole breath cycle.[12] However, anesthesiologists have been reluctant to use PEEP since it could lead to cardiac compromise, mandating volume expansion and perhaps even vasoactive drugs.[13] Notably, in the randomized controlled trial mentioned above comparing ventilation with a low V_T (6mL/kg predicted PBW) with ventilation with high V_T (10mL/kg PBW) in critically ill patients with uninjured lungs,[5] an independent association between use of higher levels of PEEP and the development of the acute respiratory distress syndrome was observed. The three RCTs of intraoperative ventilation mentioned above actually compared bundles of lung-protection: low V_T with high levels of PEEP, and high V_T without PEEP.[8-10] It is not possible to conclude from these trials whether benefit was due to use of low V_T or higher levels of PEEP or both, but one recently published RCT in non-obese patients undergoing planned abdominal surgery comparing intraoperative ventilation with low levels of PEEP (0 - 2cmH_2O) with high levels of PEEP (12cmH_2O), showed no differences between the two randomization arms with respect to the occurrence of postoperative pulmonary complications.[13] In that RCT, use of the higher PEEP levels was associated with intraoperative hypotension and higher need for vasoactive drugs.[13] A recent metaanalysis including data from the larger RCTs mentioned above and several other investigations of ventilation in the operating room confirm that high levels of PEEP do not prevent postoperative pulmonary complications when low V_T are used.[14] It could very well be that a minimum of 2cmH_2O of PEEP is sufficient in most patients, and that further increases should be individualized, e.g., based on oxygenation. We cannot exclude, though, that obese patients or patients undergoing laparoscopic abdominal surgery during which insufflation of gas in the abdominal cavity could induce more atelectasis, do benefit from higher levels of PEEP, but randomized controlled trial evidence is lacking.

OXYGEN FRACTIONS

Seen the uncertainties surrounding the use of PEEP in the operation room, anesthesiologist may want to improve oxygenation with the use of higher FiO_2, despite the fact that this could induce reabsorption atelectasis[3] and increase the production of reactive oxygen which could injure cellular structures.[3] There is increasing evidence that both ventilation with high FiO_2 and/or high arterial oxygen levels are associated with increased mortality in critically ill patients, an effect that appears to be independent of other factors than disease severity.[3] At present, there are no sufficiently powered trials that investigated the effects of higher FiO_2 on occurrence of postoperative pulmonary complications. Despite the evidence for harm of high FiO_2 in non-surgical patients, higher levels of FiO_2 are increasingly used, as suggested by the report on intraoperative ventilation practices in university hospitals in the USA mentioned above.[11]

FUTURE STUDIES

At present several RCTs of intra-operative ventilation are running, including the international 'Protective Ventilation With Higher Versus Lower PEEP During General Anesthesia for Surgery in Obese Patients' (PROBESE) trial,[15] the French trial comparing protective to conventional ventilation (V_T of 5mL/kg PBW plus PEEP vs. V_T of 10mL/kg PBW without PEEP) in surgery for lung cancer,[15] and the international 'Protective Ventilation With Higher Versus Lower PEEP During General Anesthesia for Thorax Surgery' (PROTHOR).[15] The results of these trials all have the potential to further improve safety of intra-operative ventilation.

CONCLUSIONS

We advise to use low tidal volume, low levels of positive end-expiratory pressure, and low levels of low oxygen fractions during intra-operative ventilation.

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