Postoperative lung complications: have multicentre studies been of any help?

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That the oxygenation of blood is impaired during anaesthesia and that postoperative lung complications may occur have been known for a long time. A number of multicentre studies have appeared during the last few years with the intention to reduce lung complications by decreasing atelectasis and lung strain. The former can be achieved by increasing lung volume and the latter by reducing tidal volume. But when and how shall it be done and is it of any help at all? Convincing but opposite conclusions have been drawn in many of these studies leaving clinicians (and scientists) at a loss. A multicentre study is an ultimate test of a treatment and its results may have greater impact on clinical routines than a smaller, single-centre study. But is plentiful better than thoughtful? Results can be misinterpreted if the studied concept is not fully understood, conclusions may be erroneous, and recommendations may be harmful. This commentary aims at analysing why we have this confusion and what we might do to increase our understanding of perioperative lung function.

The resting lung volume (functional residual capacity, FRC) is reduced during anaesthesia, promoting airway closure and atelectasis (Fig. 1). The former causes ventilation/perfusion mismatch and the latter shunt and both impede oxygenation.2,11 Atelectasis has also been considered a locus for infection.1,4 Airway closure and atelectasis will be prevented if FRC is restored. This can be achieved by the application of a suitable PEEP and by recruitment manoeuvres.1,2 The use of continuous

References
1 Overton E. Studien über die Narkose zugleich ein Beitrag zur allgemeinen Pharmakologie. Jena, Germany: Verlag von Gustav Fischer, 1901
2 Thunberg T. Ernest Overton. Skandinavisches Archiv Für Physiologie 1934; 70: 1–9
4 Overton CE. On the reduction of chromosomes in the nuclei of plants. Annals of Botany 1893; 7: 139–43
5 Kanna A. Membrane Permeability: 100 Years Since Ernest Overton. San Diego: Academic Press, 1999
7 Höber R. Physikalische Chemie der Zelle und der Gewebe, 5th Edn. Leipzig, Germany: Verlag Wilhelm Engelmann, 1924
8 Lepeschkin WW. My opinion about protoplasm. Protoplasma 1930; 9: 269–97
16 Plowe JQ. Membranes in the plant cell I. Morphological membranes at protoplasmic surfaces. Protoplasma 1931; 12: 196–221
18 Lipnick RL. A QSAR study of Overton’s tadpole data. Prog Clin Biol Res 1989; 291: 421–4
positive airway pressure (CPAP) during induction of anaesthesia, followed by PEEP, keeps FRC continuously elevated. However, the effect of recruitment manoeuvres and PEEP may be lost during the emergence from anaesthesia and may not last into the postoperative period. How long the effect of a recruitment manoeuvre persists depends on the inspired oxygen concentration; the lower the oxygen concentration is the longer is the preventive effect against atelectasis. Other aspects of inspired oxygen concentration during anaesthesia have been previously discussed in a meta-analysis and correspondence. CPAP-breathing during emergence from anaesthesia prevents or reduces atelectasis and postoperative CPAP protects against lung complications. An open lung after the anaesthesia may thus be an important goal.

More recently, the tidal volume (V1) has come into focus, assuming that the beneficial effect of reduced V1 in intensive care, from 15 to 6 ml kg\(^{-1}\) or even less, may also apply to anaesthesia and surgery. There may be good reasons. In a healthy, awake subject, V1 is around 500 ml, corresponding to 6–7 ml kg\(^{-1}\). This V1 is delivered to a gas volume (FRC) of ~3–4 litre. FRC approaches 2 litre during anaesthesia which is close to residual volume but still much larger than in acute lung injury where lung volume may be as low as 0.5 litre. The normal lung in the anaesthetized patient may also tolerate increase in airway/alveolar pressures and volumes better than the sick lung, as suggested by experimental studies. However, the surgical trauma may induce an inflammatory response that makes the lung more vulnerable to increased airway pressures.

To address hypoxaemia and postoperative lung complications, recent studies have used recruitment manoeuvres and PEEP with the intention to keep the lung open and low tidal volume to avoid lung strain. The results speak in favour of this concept of ‘protective ventilation’ but whether low V1 or recruitment manoeuvres and PEEP is important, or both, is not clear. In a recent commentary, a critical notion was made on the belief that low V1 is the important part of ‘protective ventilation’, despite that those receiving low V1 also were given recruitment manoeuvres and a PEEP of 6–8 cm H\(_2\)O. A modified opinion by those favouring low V1 appeared in still another commentary, emphasizing that PEEP should be given from start of anaesthesia and all the way into the postoperative period. In a study comparing low and high V1 at similar PEEP of 5 cm H\(_2\)O, no beneficial effect was seen by the lower V1. Also, there was no difference in inflammatory mediators in patients receiving a V1 of 6 or 10 ml kg\(^{-1}\). In still another recent multicentre study, no beneficial effect of the ‘open lung’ approach (recruitment and as high PEEP as 12 cm H\(_2\)O) was seen, and postoperative lung complications (38% incidence) were similar whether recruitment and PEEP were used or not. This high complication rate may be seen in ‘high risk’ patients, although 5–10 times higher than what is commonly reported, and it raises the question whether the studied ventilation modes had any substantial influence on the complication rate. The impression given by all these studies is that we are still left with uncertainty. Is it mainly the anaesthesia, or the emergence, or the postoperative period that may initiate lung complications? Are measures to keep the lung open and the strain low (small V1) during anaesthesia of any value if these precautions are lost during the emergence from anaesthesia? And, the other way around, does it matter whether there is some lung collapse during anaesthesia if the lung is fully open when the patient is delivered to the postoperative ward and later to the general ward? Are recruitment manoeuvres and PEEP safe and does a decrease in V1 reduce strain or any other measure of physical load on the lung? Does one size of PEEP or recruitment fit all?

Thus, there are more steps to test in finding an optimal ventilation technique during and after anaesthesia. They should preferably be considered before any large multicentre study tries another short-cut.

**Declaration of interest**

None declared.

**References**

Anaesthetists provide personalized care. Preoperative assessment guides decision-making, and awareness of risk based on clinical experience allows anaesthesia to be conducted in a way that aims to achieve the best possible clinical outcome for each patient while minimizing side-effects. This traditional approach has led to the use of a wide variety of good, safe anaesthetic techniques.

Making sense of clinical outcomes becomes much more complex when one considers that the nature of anaesthesia may change simply according to an intelligent clinical ‘hunch’ rather than written evidence; what the anaesthetist feels and fears based on training and experience is important in delivering good care.

Conversely, a number of well-intended protocol-based approaches to delivery of anaesthesia and postoperative pain relief have recently been undertaken. The Prospect group took a protocol-based approach; for specific surgical procedures, a consensus was reached between experts and

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**References**


7 Hedenstierna G, Edmark L. Does high oxygen concentration reduce postoperative infection? *Anesthesiology* 2014; 120: 1050


18 Goldenberg NM, Steinberg BE, Lee WL, Wijeysundera DN, Kavanaugh BP. Protective ventilation in the operating room: time to implement? *Anesthesiology* 2014; 121: 184–8

19 Futier E, Morret E, Jaber S. Perioperative positive pressure ventilation. An integrated approach to improve pulmonary care. *Anesthesiology* 2014; 121: 400–8


22 The PNI, for the Clinical Trial Network of the European Society of Anaesthesiology. High versus low positive end-expiratory pressure during general anaesthesia for open abdominal surgery (PROVHILO trial): a multicentre randomised controlled trial. *Lancet* 2014; 388: 495–503


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**‘Stratified’ approach to individualized anaesthetic care**

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