The intrapulmonary oxygen store

Editorial overview

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Both physiological and anaesthesiological investigations continue to augment our knowledge of the intrapulmonary oxygen reserve with particular impact on our management of the difficult intubation. Every respiratory arrest immediately ceazes oxygen supply while oxygen consumption continues with approx. 200–250 ml per minute. This apnea can be survived for about 2–4 minutes by consuming particularly the intrapulmonary oxygen store. However, apnea must be induced for endotracheal intubation – in Germany about 10 thousend patients per day. This every-day clinical experience routinely teaches that difficulties of intubation are much more common than published cases would allow to expect. But, even if the procedure finally has become to be successfully managed, still the "can't intubate, can't ventilate" cases remain as the major challenge. Consequently, realistic data attribute routine inductions to a 2% rate of difficult intubations, i.e. more than 200 cases per day regarding Germany: without any warning signals being previously obvious to the anaesthetist. The clinical use of the intrapulmonary oxygen store, therefore, must be of outstanding interest since it represents the single oxygen reserve that can be used therapeutically.

Zander and *Mertzlufft*, in reviewing the most recent contributions to the area of oxygenation during apnea, reinforce the possibility for humans to survive apneas of at

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least one hour without any ill effects explaining this phenomenon by means of simple calculations of the intrapulmonary oxygen store. They particularly clarify such terms pre-oxygenation, i.e. the filling of the intrapulmonary oxygen store prior to apnea of intubation, and apneic oxygenation, i.e. O_2 uptake despite respiratory arrest. Optimal pre-oxygenation, additionally is introduced as the anticipated goal for filling the 3,000 ml volume of the functional residual capacity (FRC) with 100 % oxygen only. Necessary preconditions for this procedure are both the total nitrogen washout of the FRC as well as the total stop of any nitrogen entrainment. Successful management of both requirements provided, the FRC will contain about 90 % oxygen, i.e. an intrapulmonary oxygen store of approx. 2,500 ml that guarantees sufficient O_2 supply during 10 minutes of apnea. Following optimal pre-oxygenation patients can "breathe" despite ongoing apnea and survive even an apneic period of one hour if the gas taken up by the patient is nothing but pure oxygen. This impressive phenomenona – of oxygen uptake despite apnea – has been first described in 1908 by the German surgeon *Franz Volhard*, and some decades later was termed as apneic oxygenation. This apneic oxygenation is created by the oxygen uptake of e.g. 200 ml/min (from the lungs into the blood) on the one hand and, on the other, by the delivery of approx. 20 ml of carbon dioxide (from the blood into the lungs), thus causing a gas or oxygen "suction" of 180 ml. Consequently, only 20 ml of the intrapulmonarily stored 2,500 ml of oxygen (due to optimal pre-oxygenation) are consumed per minute of apnea. As demonstrated in 1959 by *Frumin, Epstein* and *Cohen* this effect may guarantee survival for even 55 min of apnea.

Brandt, Rudlof and *Merkelbach*, in their review, examine whether pre-oxygenation must be considered as "a nice physiological tool" or as an "integral part of anaesthesiological routine practice". They emphasize that, despite representing a simple and unexpensive procedure, routine pre-oxygenation is not performed in too many hospitals at all, and that optimal pre-oxygenation should be a must for every anaesthesist. However, reviewing the respective literature enforces them to give strong advice for a profound improvement of the contemporary methods actually used for pre-oxygenation.

This special aspect, i.e. the disadvantages of pre-oxygenation methods available, is particularly examined by *Voigt*. His analysis of the most widespread used system, the Dräger circle circuit, discloses that, applying optimized procedures for the necessary denitrogenation of circle circuit plus FRC (e.g. initial flushing of the system), is most obstaculous and time consuming.

Frei and *Ummenhofer* focus on the paediatric pre-oxygenation which requires particular interest and skill. In case of an awake child of 6.5 kg BW, they conclude, O_2 consumption during apnea is only guaranteed for about 4 minutes despite the FRC totally filled with pure oxygen, contrary to about 11 minutes of safe oxygenation for an adult of 65 kg BW. They strongly recommend, therefore, to pre-oxygenate every child for more than at least one minute.

Finally, *Mertzlufft* and *Zander* peer into the future to describe a new system for the oxygenation of patients which, according to it's special features, has been recently introduced as the so-called "NasOral"-System allowing for both optimal pre-oxygenation and apneic oxygenation as well. Based on the principle of unidirectional flow, this system provides uptake of pure O_2 solely via the nose (nasal route) comprising a reservoir bag and a special nose mask including a one-way valve, and additionally comprising a second one-way valve inserted into the mouth of the patient (oral route), thus enforcing the required directed oxygen flow (nasal-oral route). The authors, in examining the system, especially focus on the advantage of that system of filling the FRC almost completely with pure oxygen within one minute, only. More over, they identify the ongoing oxygenation during the intubation procedure, i.e. with the oral valve being removed in that case, as being beneficial and having major impact on patient safety during apnea of intubation.In conclusion, the present contributions seem to support a recent Editorial on preoxygenation published in The Lancet 1992 (vol 339, pp 31–32), demanding the improvement of the contemporary clinical anaesthetic practice.

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