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 ceases 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 20 thousand patients per day. This everyday 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 Mottzaffi, in reviewing the most recent contributions to the area of oxygenation during apnea, reinforce the possibility for humans to survive apneas of at
least one hour without any ill effects explaining this pheno-
menon by means of simple calculations of the intrapulmon-
ary oxygen store. This particularly clarifies such terms pre-oxygen-
ation, i.e., the filling of the intrapulmonary oxygen store prior to
apnea of intubation, and apneic oxygenation, i.e., O₂ uptake
despite respiratory arrest. Optimal pre-oxygenation, addition-
ally is introduced as the anticipated goal for filling the 3,000 ml
volume of the functional residual capacity (FRC) with 100% 
oxigen only. Necessary precautions for this procedure are
both the total nitrogen washout of the FRC as well as the total
stop of any nitrogen re-enainment. Successful management of
both requirements provided, the FRC will contain about 90% 
oxigen, i.e., an intrapulmonary oxygen store of approx.
2,500 ml that guarantees sufficient O₂ supply during 10
minutes of apnea. Following, optimal pre-oxygenation patients
can "breathe" despite ongoing apnea and survive even an ap-
neic period of one hour if the gas taken up by the patient is
nothing but pure oxygen. This impressive phenomenon – of
oxygen uptake despite apnea – has been first described in 1908
by the German surgeon Franz Valhard, and some decades
later was termed as apneic oxygenation. This apneic oxygena-
tion 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 minutes of apnea. As demonstrated in 1959
by Frumkin, Epstein and Cohen this effect may guarantee sur-
vival for even 55 min of apnea.

Brandt, Rudloff and Merkellbach, in their re-
view, examine whether pre-oxygenation must be considered
as "a nice physiological tool" or as a "integral part of anes-
thesiological routine practice". They emphasize that, despite
representing a simple and inexpensive procedure, routine
pre-oxygenation is not performed in too many hospitals at all,
and that optimal pre-oxygenation should be a must for every
anesthesist. However, reviewing the respective literature en-
forces them to give strong advice for a profound improvement of
the contemporary methods actually used for pre-oxygena-
tion.

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 obstica-
lous and time consuming.

Pre and Limmenhofer 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, O₂
consumption during apnea is only guaranteed for about 4
minutes despite the FRC totally filled with pure oxygen, con-
trary to about 11 minutes of safe oxygenation for an adult of
65 kg BW. They strongly recommend, therefore, to pre-oxygen
every child for more than at least one minute.

Finally, Mentz and Zander peer into the
future to describe a new system for the oxygenation of patients
which, according to its special features, has been recently in-
troduced as the so-called "Nasal Oral" System allowing for both
optimal pre-oxygenation and apneic oxygenation as well.
Based on the principle of unidirectional flow, this system pro-
vides uptake of pure O₂ 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 direct flow 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 pro-
ceedure, i.e., with the oral valve being removed in that case, as
being beneficial and having major impact on patient safety dur-
ing apnea of intubation. In conclusion, the present contribu-
tions seem to support a recent Editorial on preoxygenation
published in The Lancet 1992 (vol 339, pp 31 – 32), demand-
ing the improvement of the contemporary clinical anaesthetic
practice.

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