Oxygenation during one-lung ventilation

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Two patients in our hospital experienced arterial hypoxaemia during one-lung ventilation (OLV) whenever their cardiac outputs decreased. Arterial oxygenation during OLV is determined not only by the magnitude of the intrapulmonary shunt, but also by cardiac output, hemoglobin concentration [Hb], and oxygen consumption. Theoretically, the relationships between these variables can be understood by regarding the shunt equation, as well as the Fick equation for oxygen consumption. Solving the shunt equation for arterial oxygen content (CaO2) gives:

$CaO_2 = C\acute{c}O_2.(1 - Qs/Qt) + (Qs/Qt).C\text{''}O_2$ Equation-1

Mixed venous content ($C\text{''}O_2$) is given by solving the Fick equation:

$C\text{''}O_2 = CaO_2 - [VO_2/Qt]$ Equation-2

Where: $C\acute{c}O_2$ = oxygen content of capillary blood
Qs = intrapulmonary shunt
Qt = cardiac output

These equations may be combined into a single equation.[1]

Qs/Qt
$CaO_2 = C\acute{c}O_2 - (VO_2/Qt) *$ ---------- Equation-4 $10*(1 - Qs/Qt)$

Equation-4 may be used to construct plots to illustrate the relationship between arterial oxygen content and cardiac output. In addition, it is possible to illustrate by means of these plots how varying Qs/Qt, [Hb] and VO_2, influences CaO_2.

All the variables contained in Equation 4 should be controlled by the anaesthesiologist to maintain adequate arterial oxygenation during OLV. Note that the most important determinant of $C\acute{c}O_2$ is the haemoglobin concentration. An important determinant of CaO_2 in Equation 4 is the ratio VO_2/Qt. This ratio is in turn governed by $C\text{''}O_2$ (Equation 2). $C\text{''}O_2$ should therefore be assiduously monitored and optimized during OLV.

Reference:

1. *Kelman GR, Nunn JF, Prys RC, et al. The influence of cardiac output on arterial oxygenation: a theoretical study. Br J Anaesth 1967; 39:450–458.*