

## The need for peri-operative supplemental oxygen

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Molecular oxygen is a colourless and odourless gas which is essential to life. It accounts for 21% of the atmospheric air. Apart from its central role in oxidative phosphorylation to produce biological energy in the form of adenosine triphosphate (ATP), molecular oxygen is used as substrate by two other enzyme systems for the killing of bacteria in the phagocytes and for collagen synthesis by the fibroblast during wound healing.<sup>1-8</sup> In the immediate post operative period atmospheric oxygen might become inadequate for a number of reasons including hypoventilation due to central pharmacological depression, diffusion hypoxia and increased metabolic rate due to shivering (the so called halothane shakes).<sup>9-11</sup>

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### Effect of oxygen on myocardium and central nervous system.

Peri-operative hypoventilation decreases minute volume which results in hypoxic hypoxia.<sup>12-14</sup> Shivering on the other hand, increases skeletal muscle metabolic rate which, if supplemental oxygen is not available, leads to increased lactic acid production and metabolic acidosis.<sup>9,11</sup> Such events may have catastrophic results in patients with concurrent disease like coronary artery disease.<sup>15-17</sup>

Post operative supplemental oxygen has been shown to be beneficial in counteracting nocturnal hypoxia and reducing ischaemic events in patients who have ischaemic heart disease.<sup>13,16-18</sup> Nocturnal hypoxic dips tend to occur from second to third day post-operatively. Myocardial infarction tends to occur within six days post operatively with a peak around the third day.<sup>19</sup> Supplemental oxygen beyond three days might, therefore, be necessary to counteract ischaemic episodes especially when the patient is sleeping.

Supplemental oxygen peri-operatively is of benefit to hypotensive and/or anaemic patients. Increasing the fraction of inspired oxygen (FiO<sub>2</sub>) from 21% to 100% results in a six fold increase in the content of dissolved oxygen.<sup>20</sup> This becomes an important component in the oxygen delivery equation *vida infra*.

### Effect of oxygen on resistance to wound infection.

Apart from these metabolic benefits supplemental oxygen has been shown to reduce the incidence of post operative nausea and vomiting by half.<sup>21</sup> The mechanism is not clear but seems to be related to prevention of cerebral hypoxaemia.

The bactericidal activity of neutrophils is mediated by oxidative killing using molecular oxygen as substrate.<sup>22-24</sup>

Bactericidal superoxide radicals are formed from molecular oxygen catalysed by nicotinamide adenine dinucleotide (NADPH)-linked oxygenases. This crucial step is dependent on high tissue partial pressure of oxygen.<sup>22</sup>

$$CaO_2 = (Hb \times SaO_2 \times 1.34) + (PaO_2 \times 0.025kPa) \text{ mL/dL}$$

$$dL : O_2 \text{ Flux} = CaO_2 \times QT \times 10$$

*CaO<sub>2</sub>* = arterial O<sub>2</sub> content; *PaO<sub>2</sub>* = partial pressure of O<sub>2</sub>; *Q T* = cardiac output; *SaO<sub>2</sub>* = arterial O<sub>2</sub> saturation

Since phagocytes (neutrophils, macrophages) are recruited to the surgical site, the overall effect of supplemental oxygen is to increase bactericidal capacity of polymorphonuclear cells and prevent wound infection. Hypoxia on the other hand, which may occur if supplemental oxygen is not given, has been shown to reduce neutrophil bacterial killing mechanisms.<sup>25</sup> Several studies have shown that supplemental oxygen has surgical advantages. Wound infection, and tissue necrosis are serious surgical complications which can be modified by supplemental oxygen in the peri-operative period.<sup>26,27</sup>

In patients undergoing colorectal resection procedures it has been shown that administration of high oxygen concentration (80%) during surgery and supplemental oxygen (80%) for at least two hours post operatively, reduces the incidence of wound infection by half in comparison to patients given the treatment of 30% oxygen during operation and for two hours post operatively.

Delivery of oxygen to tissues is linked to tissue perfusion. Supplemental oxygen without adequate tissue perfusion is not effective in reducing wound infection.<sup>27</sup> When the peripheral perfusion is normal, the subcutaneous tissue partial pressure of oxygen is linearly related to arterial

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partial pressure of oxygen (PaO<sub>2</sub>) and inversely related to the rate of wound infection.<sup>26-28</sup>

Effect of oxygen on wound healing.

Supplemental oxygen has been shown to increase resistance to infection and measurements of subcutaneous tissue oxygen tension could predict the risk of wound infection in surgical patients.<sup>27</sup> Tissue oxygen tension can be measured by tissue oximetry and is a better method of assessing tissue perfusion than other parameters like urine output, which does not show an appreciable reduction until a 30% fall in circulatory volume.<sup>29</sup> Tissue oximetry picks up early changes in blood volume. In fact increase in peripheral perfusion correlates linearly with tissue oxygen tension.<sup>29-31</sup>

Supplemental oxygen given post-operatively promotes wound healing.<sup>32</sup> High tissue oxygen tension is essential for optimum collagen synthesis in surgical wounds.<sup>8,32,33</sup> The hydroxylation of proline and lysine residues of collagen by prolyl and lysyl hydroxylases respectively, in the fibroblast requires oxygen.<sup>4,5</sup> Low tissue oxygen tension results in reduced collagen accumulation in surgical wounds.<sup>8,32,33</sup>

Thus supplemental oxygen in the peri operative period is vital for both anaesthetic and surgical reasons in order to reduce morbidity and improve outcome. Provision of supplemental oxygen is a relatively simple maneuver with invaluable benefit to the patient. For maximum benefits on myocardial function and collagen accumulation supplemental oxygen is recommended for three days continuously in the presence of good peripheral tissue perfusion. For infection prophylaxis supplemental oxygen has to be given during surgery and for at least two hours post operatively.<sup>28</sup> Infection prophylaxis by 80% oxygen during the operation and for two hours post operatively can be recommended for all surgical patients but a prolonged period of supplemented oxygen in excess of two hours post operatively should be prescribed by the anaesthetist or surgeon according to the guidelines indicated above. Adequate peripheral tissue perfusion can be ensured by maintaining adequate hydration.<sup>33</sup>

In summary, we suggest supplemental oxygen be given peri-operatively to decrease myocardial complications, decrease wound infections and promote wound healing.

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