2.4 Pulse oximetry training methods

In poorer parts of the world, most preventable anaesthesia morbidity and mortality is related to airway and respiratory problems leading to hypoxia. Hypoxia is difficult to detect clinically, particularly in dark skinned patients, and a pulse oximeter gives an early warning of these events. If anaesthesia providers can correctly interpret the information displayed by an oximeter and respond effectively to treat the cause of hypoxia and prevent it from worsening, many patients who might otherwise die during anaesthesia and surgery will be saved.

Although pulse oximetry is a relatively simple and reliable technology, successful use is dependent on a number of important issues. Providers need to know how to operate the oximeter, its alarms and menus, and how to attach it to the patient. They need to understand the common reasons for hypoxic readings in anaesthetised patients and how to diagnose the causes of hypoxia during anaesthesia. They also need to be able to interpret oxygen saturation in relation to the physiology of oxygen transport, taking into account the concentration of haemoglobin in the blood and any causes of increased metabolic rate (such as pregnancy, sepsis, etc.) and respond to hypoxia during anaesthesia. This includes the ability to distinguish artefactual readings. In addition to the clinical aspects of oximetry, providers and anaesthesia personnel must know how to maintain and clean the apparatus between patients and must understand how to maintain the charge in a rechargeable battery. The local arrangements for servicing or replacing a device and its probes are also critical for sustained oximetry use.

In order to ensure benefit from promoting the universal use of oximetry during anaesthesia, providers from a variety of backgrounds will need to learn how to use and care for oximeters, how to interpret oximeter readings, and how to respond to hypoxia. This will require specific educational materials that are easily understood by all potential users. The Global Oximetry (GO) Project has piloted some educational material during its projects in Uganda, Vietnam, India and the Philippines. The experience of the project members is instructive and should be considered while developing the training program:

- Educational levels of anaesthesia providers varied significantly. The most sophisticated clinicians were well educated physician anaesthesiologists in financially constrained hospitals. There were also nurse anaesthetists and technically trained non-medical anaesthetists with appropriate knowledge and skill. Finally, there were providers with some practical skills but very little theoretical knowledge of medicine, physiology, pharmacology or anaesthesia.
- Highly trained physicians and nurses who are not familiar with the use of oximetry may not understand its fundamental concepts or what it hopes to achieve. Although it might be assumed that qualified medical personnel will understand the use of oximetry, this was not the experience in the UK following the introduction of this technology, nor of the GO project. However, such individuals have a reasonable base of theoretical knowledge to build on.
- The physiology of oxygenation and ventilation is quite sophisticated; simplistic and didactic teaching of oximetry is likely to lead to failures while
interpreting the clinical situation. Alveolar ventilation, ventilation/perfusion ratio, shunt fraction, diffusion across the alveolar-capillary membrane, barometric pressure, inspired oxygen concentration, mixed venous oxygen concentration all influence the arterial partial pressure of oxygen. The delivery of oxygen also depends on cardiac output, the concentration of haemoglobin in the blood, and the oxygen-haemoglobin (Hb) dissociation curve which may shift in response to various physiological changes.

- Oxygen saturation readings must be correctly interpreted. Because of the shape of the oxygen-Hb dissociation curve, hypoxaemia starts to occur with oximeter readings below 90-93% and becomes rapidly worse. This is quite different to many examination systems, where marks of over 70% are regarded as very good. Even if a simplistic approach to teaching is adopted, this difference needs to be clearly understood.

- Language can be a significant barrier to educational initiatives. Materials can be translated, but it is difficult to be confident of the accuracy of the translation particularly in relation to more subtle concepts. The translation of medical terms and concepts is a specialised endeavour. Reading levels may also be variable and educational materials should strive to be as clear and succinct as possible.

- Many countries have at least some access to online web-based facilities. This creates the potential for interactive tools to teach physiological concepts. An example can be seen at the Virtual Anaesthesia Machine (VAM) website (http://vam.anest.ufl.edu) which includes a useful demonstration of the alveolar gas equation.

- Participants in these educational programs are typically adults experienced in the practicalities of providing anaesthesia in their own environment. Such people tend to respond well to interactive educational techniques involving facilitated discussions (including discussions of case scenarios), questions and answers, and simulation (which can be fairly simple – see for example the VAM website). This approach, using translators if necessary, is more likely than didactic lecturing to identify failures in communication and conceptual understanding. It is also more flexible for responding to the actual needs of students.

- Evaluation is an important element of training and some form of testing is appropriate to ensure that educational objectives have been met. Documentation of educational achievement through certificates is usually appreciated.

As pulse oximetry is introduced into different countries and healthcare sectors, the learning requirements of anaesthesia providers should be assessed and training should be modified to account for this. The following recommendations should be considered as this training program takes shape:

- Resources should be as language-free as possible. This is facilitated by emphasizing graphical material rather than relying solely on texts.
- Not withstanding the above, local language teaching materials are essential.
- Theoretical and practical training and assessment should be carried out for each anaesthesia provider.
- Specific anaesthesia scenarios and action plans for hypoxic patients should be included in the training materials and presented in an interactive discussion format.
- Local trainers should be recruited and trained, as this provides a sustainable mechanism for training colleagues in different parts of the country and in different hospitals.
- Reasonable time (ideally an entire day) should be allocated for both training during the initial introduction of pulse oximetry into a country or facility and for assessment of oximetry naïve anaesthesia providers.
- Supplementary training to reinforce educational goals and clinical skills should be provided at least annually during the first two or three years.
- Oximetry provides a focus around which many key principles of safe anaesthesia practice can be taught and illustrated.