Reflectance Spectrophotometry and Tissue Oxygenation in Experimental and Clinical Practice

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Introduction

Maintenance of adequate oxygen delivery (DO_2) to the tissue cells can be considered a primary objective in intensive care and peri-operative patient management. Generally, it is belived that tissue hypoxia plays a significant role in the development of organ failure in ceritically ill patients and is a major factor in the pathogenesis of multi-organ dysfunction. The introduction of regional measurement techniques has highlighted the inadequacy of the information being generated by global measurements of hemodynamic and oxygen-related variables and has focused attention on the processes underlying microcirculatory oxygenation. It should be obvious that an adequate transport of oxygen by the cardiovascular system does not guarantee ist delivery to the critical tissue of the body [1]. For this reason, assessment of tissue oxygenation is essential.

The ideal technique for the assessment of tissue oxygenation should provide quantitative, accurate, and reproducible information. Inaddition, ir should clearly distinguish which compartment is being sensed, i.e., arterial, venous microcirculatory or tissue compartmeent [2,3]. One of the techniques currently in use in both clinical and experimental practice is reflection spectrophotometry. Reflection spectrophotometry, based on absorption and scattering of reflected visible light, can provide information about hemoglobin oxygen saturation and hemoglobin concentration in tissue. Reflection spectrophotometry has been used in animal and clinical studies and is a non-invasive technique withoutn the use of special indicator dyes. Basically, reflection spectrophotometry records the difference in absorption (and partly in scattering) between a standart reference and a sample (tissue) as a form of relative absorbency. Diffuse reflection spectra from biological pigmented structures located in cells can provide us with information concerning basic mechanismsof tissue function. The first measurements of such reflection spectra were performed by Chance in the intact mitochondria [4]. In order to collect a spectrum from oxygenated or partly deoxygenated hemoglobin out of the combined spectra from divers cellular pigments, e.g., cytochromes, an algorithm is needed to extract the relevant information from the raw data. In the past, various types of reflection spectrophotometers have been developed for the assessment of tissue oxygenation, each working with a somewhat different algorithm. The next section will describe the theoretical background and technical details of two types of reflection spectrophotometers. Essentially two classes of device exist: those working with an algorithm based on the principle of isobestic points (these wavelengths where the curves of oxygenated and deoxygenated hemoglobin intersect), using discreet exciration wavelengths [5], and those reflection spectrophotometers based on the analysis of the full reflection spectra using the theory of Kubelka and Munk as developed in Erlangen [6]. This chapter will review the use of reflection spectrophotometry in the experimental and clinical assessment of tissue oxygenation. In our discussion of the literature we will focus on investigations concerning the liver and gastrointestinal tract due to the role of splanchnic dysfunction in the pathogenesis of sepsis, leading to multi-organ failure (MOF) [7,8].