TRANSORALLY OBTAINED OXYGEN TENSION AS AN INDICATOR OF ARTERIAL OXYGEN TENSION

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ABSTRACT. Transcutaneous oxygen electrodes have been used with success in neonates as indicators of arterial oxygenation, but with less success in adults because of differences in skin thickness and vascularity. In this study a prototype transoral oxygen electrode was evaluated to determine if a heated mucous membrane would yield arterialized values of oxygen tension in adults. Using a miniaturized Clark electrode, we measured transoral oxygen tension (PtoO2) in 29 subjects at steady-state conditions. Simultaneously a sample was anaerobically obtained from a radial artery for measurement of arterial oxygen tension (PaO2). Data were analyzed using linear regression analysis, Student’s t test, and analysis of variance. There was no statistically significant difference between nonwhite and white subjects or male and female subjects. There was a highly significant difference (P < 0.001) between the pooled, matched values for PtoO2 versus PaO2, and the regression between the PtoO2 and the PaO2 was linear (slope 0.92, y-intercept -8.37, r = 0.62, P < 0.003). The calculated ratio of PtoO2 to PaO2 was 0.83 ± 0.03 (standard error). We concluded that the PtoO2 was linearly related to the PaO2, although its accuracy in reflecting PaO2 was low. This finding correlates with previously published data that suggested that the PtoO2 reflects tissue oxygen tension rather than arterialized oxygen tension. Gender and race appeared not to affect the function of the electrode in our study.


The transcutaneous oxygen electrode, a modification of the polarographic oxygen electrode first described by Clark, was originally conceived as a continuous and noninvasive indicator of arterial oxygenation [1,2]. Arterialization of the capillary bed is achieved by heating the skin to a temperature of 43 to 45°C, causing vasodilatation, increased blood flow, and enhanced oxygen diffusion [1]. Oxygen is reduced at the cathode of the electrode, leading to an electrical potential difference and, therefore, the generation of a current that is proportional to the number of oxygen molecules present. More recently, the measurement of transcutaneous oxygen tension (PtcO2) has been thought to represent tissue oxygen tension rather than arterial oxygen tension (PaO2), because the amount of oxygen present at the tissue surface depends on the magnitude of blood flow to the tissue and diffusion of oxygen from the capillary bed to the surface of the electrode. This diffusion may be hampered by differences in skin thickness, tissue vascularity, and tissue oxygen uptake [1,2].

The transcutaneous oxygen electrode, when used in neonates, has yielded a high correlation between mea-
when normal cardiac output and perfusion are maintained, peripheral vascularity and thin skin, this correlation is high for normal values [1,3-5]. Because of the neonate’s increased peripheral vascular insufficiency and thin skin, this correlation is high when normal cardiac output and perfusion are maintained [1,5].

The transcutaneous oxygen electrode has been used in adults as an indicator of oxygenation in critically ill patients [6-12] during one-lung anesthesia [13] and bronchoscopic procedures [14], and in the evaluation of peripheral vascular insufficiency [15,16]. However, the transcutaneous continuous measurement of oxygen tension as a substitute for the measurement of PaO2 in adults has been hampered because of perfusion-related variables, such as differences in skin thickness and vascularity [2]. Although high correlation with PaO2 has been achieved in the presence of a normal cardiac output, the accuracy in reflecting absolute PaO2 has been low [6,7,9,17].

To compare PaO2 and PtcO2 measurements, a transcutaneous index, defined as PtcO2/PaO2, has been reported. The average transcutaneous index in adults has been reported to be 0.79 to 0.83 [5,6,8].

In an effort to overcome problems relating to perfusion-related variables, two types of transtissue oxygen electrodes have been devised so that they can be applied to the mucous membranes: the conjunctival and the transoral electrodes [18,20]. The mucous membranes have the theoretical advantage over skin surfaces of being thin and highly vascular, similar to the tissue conditions found in neonates.

The conjunctival oxygen tension electrode has been shown to be useful in adults as a trend indicator of arterial oxygenation [19-22], demonstrating a faster response time than the transcutaneous oxygen electrode [20,22]. Stabilization time is reduced because no heating is required; this is due to the increased vascularity of the palpebral conjunctiva, the absence of a stratum corneum, and a thin epithelial layer [19,23,24]. Because this tissue bed is supplied by the internal carotid artery, the conjunctival oxygen electrode has been used as an indicator of cerebral oxygenation during carotid endarterectomy [25]. Disadvantages of this electrode include the theoretical risk of damage to the eye [26] and the marked variability in the ratio of conjunctival oxygen tension to PaO2, even among healthy individuals [27].

The transoral oxygen electrode was devised to eliminate some of the disadvantages of the conjunctival sensor and still interface with a highly vascular mucosa [18]. In this study, a prototype transoral oxygen electrode was evaluated to determine if heating of mucous membrane surfaces would yield arterialized values of oxygen tension.