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Transcutaneous pO₂ imaging during tourniquet-induced forearm ischemia using planar optical oxygen sensors

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Abstract:

Background: Oxygen dependent quenching of luminescence using transparent planar sensor foils was shown to overcome the limitations of the polarographic electrode technique in an animal model. This method was then transferred to a clinical setting to measure the transcutaneous pO₂ (p_{tc}O₂).

Methods: In six healthy subjects, a cuff on the upper arm was occluded up to 20 mmHg above systolic pressure and released after 8 min. P_{tc}O₂ was measured at the lower arm every 30 s before, during, and up to 20 min after cuff occlusion (40 °C applied skin temperature) using luminescence lifetime imaging (LLI) of platinum(II)-octaethyl-porphyrin immobilized in a polystyrene matrix. For validation, the polarographic Clark electrode technique was applied in close proximity, and measurements were conducted simultaneously.

Results: P_{tc}O₂ measurements before (70.8 ± 19.1 vs. 66.2 ± 7.7 mmHg) and at the end of ischemic (2.7 ± 1.2 vs. 3.6 ± 1.7 mmHg) and reperfusion phases (72.2 ± 3.6 vs. 68.4 ± 8.9 mmHg) did not differ significantly using the Clark electrode vs. LLI. At both the initial ischemic and the reperfusion phases, the Clark electrode measured a faster decrease or increase, respectively, in p_{tc}O₂ because of the oxygen consumption occurring in this method.

Conclusion: The presented method provides accurate and reproducible p_{tc}O₂ values under changing microcirculatory conditions. The lack of oxygen consumption during measurement allows both a more realistic estimation of p_{tc}O₂ than compared with the gold standard and permanent use in regions with critical oxygen supply.

Key-words: Microcirculation, Luminescence lifetime imaging, Two dimensional, Clark electrode