

Measurement of transcutaneous oxygen tension in patients with diabetic foot complications

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Examination of peripheral pulses and peripheral blood pressures are commonly used methods for investigation of macrocirculation. However, falsely elevated peripheral blood pressures may complicate the accurate prediction of ulcer healing in diabetic patients. Because $tcpO_2$ also measures the nutritive skin capillary circulation in addition to macro- and microcirculation, transcutaneous oxygen measurements are better predictors for healing of chronic diabetic foot ulcers than measurements of toe pressure.

Chronic foot ulceration is a severe complication in patients with diabetes mellitus, and 10 to 15 % of these lesions deteriorate to amputation. Neuropathy, peripheral arterial occlusive disease (PAOD) and infections are important factors contributing to the impaired healing process seen in diabetic patients. Examination of peripheral pulses and measurement of peripheral blood pressures are commonly used methods for investigation of macrocirculation.

However, important factors in the healing process of chronic foot ulcers include not only macrocirculation,

but, more specifically, the local skin microcirculation and oxygenation of the tissue surrounding the ulcer. This is emphasized by the fact that some patients with significant PAOD, indicated by reduced toe blood pressure, do not develop ischemic lesions, while others with higher toe blood pressure do [1].

Falsely elevated peripheral blood pressures due to increased calcification of the vessel walls may contribute to difficulties in prediction of ulcer healing in diabetic patients. Disturbances in the nutritive skin capillary circulation are of great importance for the healing process in diabetic patients. These functional disturbances of microcirculation are characterized by a "chronic capillary ischemia", which starts early after the onset of diabetes and are more pronounced when other complications are present, especially in patients with PAOD [2, 3].

Transcutaneous oxygen tension ($tcpO_2$) is a non-invasive method reflecting local skin blood flow and oxygenation. A reduced $tcpO_2$ level has been demonstrated in diabetic patients, even in young individuals without any evidence

of macroangiopathy [4, 5], and one explanation for this may be the skin capillary ischemia [2, 4] described above.

tcpO₂ can be used to determine severity and clinical progression of PAOD [6], and it has also proven useful for determination of the optimal amputation level [6, 7]. We have recently shown that tcpO₂ is a better predictor for healing of chronic diabetic foot ulcers than measurement of toe blood pressure [1], i.e. the positive predictive value for ulcer healing was 79 % by measurement of tcpO₂, whereas it was 67 % when measurement of toe blood pressure was used.

This study also showed that the probability of ulcer healing is decreased when tcpO₂ at the dorsum of the foot is less than 25-30 mmHg, and that the risk of major amputation is high when tcpO₂ is less than 10 mmHg. The four patients who went on to lower-limb amputation all had a very low tcpO₂ (<10 mmHg), while, in contrast, the toe blood pressure varied considerably (20-90 mmHg), which once again indicates that the local skin microcirculation is extremely important for the healing process. However, it should be observed that factors such as edema formation and thick skin may give falsely low tcpO₂ levels.

The reproducibility of tcpO₂ has been investigated earlier in healthy volunteers and in patients with PAOD and seems acceptable when the measurements are performed during submaximal vasodilatation by heating the investigated skin area to a core temperature of 44 °C. We have recently investigated the day-to-day variability of tcpO₂ (unpublished data) at the foot level in diabetic patients with PAOD, and the results show a coefficient of variation of less than 13 %, if patients with tcpO₂ lower than 10 mmHg are excluded from the calculations.

In the patients with tcpO₂ lower than 10 mmHg at the foot level, the day-to-day differences were very small (2-6 mmHg), while the coefficient of variation can be very high due to the small absolute tcpO₂ values.

In summary, measurement of tcpO₂ provides diagnostic and prognostic information in several important clinical areas, e.g. diabetic foot complications. tcpO₂ seems to be a very good complement to macrocirculatory investigations in prediction of outcome of chronic foot ulcers, suggesting that tcpO₂ in addition to local macro- and microcirculation also measures the nutritive skin capillary circulation.

References

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