Clinical Evaluation of Severe Ischemic Limbs by Tissue Reflection Spectrophotometry

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Summary: The clinical usefulness of tissue reflection spectrophotometry in the prognosis of ischemic limbs was evaluated. The diseased group (n=12) consisted of 7 cases of femoral artery thrombosis, 4 cases of chronic obstructive arteriosclerosis and 1 case of femoral vein thrombosis. The normal control group consisted of 14 limbs in 7 normal subjects (n=14). Index of tissue hemoglobin concentration (IHb) was 37.3±4.5 (n=14) in the normal control group and 38.5±16.9 (n=12) in the diseased group, which was not significantly different. In a subgroup of patients who required amputation or developed necrosis (severe subgroup), the value was 54.2±1.7 (n=6). This was significantly higher than the value of 22.8±8.5 (n=6) obtained in a subgroup of patients who received the conservative treatment of thrombectomy (mild subgroup) (p<0.05). Index of tissue oxygen saturation (ISO2) was 28.0±4.9 (n=14) in the normal control group, and 9.1±2.7 (n=12) in the diseased group (p<0.05). ISO2 was 7.0±1.6 (n=6) in the severe subgroup which was significantly lower than 11.2±1.9 (n=6) in the mild subgroup (p<0.05). Tissue reflection spectrophotometry therefore appears to provide clinically useful information for the prognosis of ischemic limbs.

Key words: tissue reflection spectrophotometer — tissue hemodynamics — ischemic limbs — prognosis — IHb and ISO2

Introduction

In the treatment of the ischemic limbs, accuracy of prognosis is very important. Radiographic studies with contrast media are most valuable in the diagnosis of peripheral arterial and venous disease, however, these procedures are invasive and risky, therefore, not suitable for use in earlier stages of the disease or for serial examination in more advanced stages of the disease. Neither arteriography nor venography provides information for prognosis. The development of non-invasive vascular studies has the advantage of avoiding the hazard of contrast radiographic procedures. The initial applications of
non-invasive or minimally invasive methods have advanced our ability to know the condition of thrombi and the changes of hemodynamics (Sigel et al. 1990). Such data are critically important to determine the clinical therapy.

This time, using a tissue spectrophotometer, we measured the tissue hemodynamics in severely ischemic limbs to evaluate the prognosis.

Materials and Methods

The measurement of peripheral hemodynamics were performed in the Critical Care Center of Kurume University School of Medicine, when the patients with ischemic limbs were admitted. The study group included 7 patients with femoral artery thrombosis, 4 patients with chronic obstructive arteriosclerosis and 1 patient with femoral vein thrombosis, and were designated the diseased group. This diseased group of 12 patients included 8 males and 4 females, with a mean age of 52.5±15.6 years. Retrospectively, a severe subgroup was designated containing those patients in the diseased group who eventually required amputation or who developed limb necrosis. Those patients who recovered or remained unchanged with conservative treatment of thrombosis were classified as the mild subgroup. Fourteen limbs of 7 normal subjects without obstructive lower extremity arterial or venous lesions served as the control and were designated the normal group. The normal group consisted of 5 males and 2 females, with a mean age of 50.3±14.5.

A tissue reflection spectrophotometer (Sumitomo Denko TS-200) was used to measure the tissue hemodynamics. The plate probe of the TS-200 was fixed to the plantar aspect of the foot using two surface tapes, taking care not to exert any compression against the foot. Measurement was performed in room air over a period of approximately 30 sec. The measured variables were index of tissue hemoglobin concentration (IHb) and index of tissue oxygen saturation (ISO₂). The systolic blood pressure remained within the range of 100-140 mmHg during the measurements in all cases.

The measurements are presented as Mean±SD. The significance of differences between means was evaluated using the Students t-test, with p<0.05 indicating a significant difference.

Results

Comparison between IHb and ISO₂ in the normal and diseased groups

IHb was 37.7±4.5 (n=14) in the normal group and 38.5±16.9 (n=12) in the diseased group (p<0.05, Fig. 1). ISO₂ was 28.0±4.9 (n=14) in the normal group and 9.1±2.7 (n=12) in the diseased group (p<0.05, Fig. 2).

Comparison between IHb and ISO₂ in the diseased subgroups

IHb was 54.2±1.7 (n=6) in the severe subgroup and 22.8±8.5 (n=6) in the mild subgroup (p<0.05). Significantly higher values were obtained in the severe subgroup (p<0.05) and significantly lower values in the mild subgroup (p<0.05), in comparison with the normal group (Fig. 3). ISO₂ was 7.0±1.6 (n=6) in the severe
Fig. 1. IHb level in the normal and diseased groups.

Fig. 2. ISO2 level in the normal and diseased groups.

Fig. 3. IHb level in the severe and mild diseased subgroups.

Fig. 4. ISO2 level in the severe and mild diseased subgroups.
subgroup, significantly lower than 11.2±1.9 (n=6) in the mild group (p<0.05). Significantly lower values were noted in both the severe and mild subgroups, in comparison with the normal group (p<0.05, Fig. 4).

Discussion

Prognosis in femoral artery thrombosis, chronic arteriosclerosis obliterans, and femoral vein thrombosis is extremely difficult to evaluate, and currently is primarily based on clinical symptoms. At the present time, angiography and the Doppler stethoscope are used in the evaluation. A quantitative method, however, would provide a more objective clinical index.

While reports are available on the measurement of ischemic limb tissue oxygen concentration (Kunze, 1969; Jussila et al. 1984; Yamamoto, 1986), invasive insertion of the electrode may present a problem and its clinical application is difficult. The tissue reflection spectrophotometer makes it possible to non-invasively measure tissue hemodynamics within a short period and with a simple procedure (Sato et al. 1979). This study was therefore designed to evaluate its ability to determine prognosis through the measurement of ischemic limb hemodynamics.

No significant difference in IHb was noted between the normal and diseased group, but the values for ISO2 were lower in the diseased group, suggesting even lower values in severely ischemic limbs. On defining severe and mild subgroups within the diseased group, the ISO2 values in the severe subgroup were even lower than in the mild subgroup, suggesting the usefulness of the degree of tissue oxygen saturation as an index of prognosis. IHb, in the severe subgroup, on the other hand, was more than twice as high as in the mild subgroup. A more useful evaluation of prognosis may be possible through evaluation of both these variables taken together. The high IHb and low ISO2 values in the severe subgroup may be explained by the blood flow stasis due to interruption of circulation, resulting in an increase in the amount of hemoglobin retained and a decrease in oxyhemoglobin. Yamamoto et al. (1989) reported significant correlations between tissue oxygen pressure (PtO2) max and levels of pH, lactate, enzymes (CPK, LDH, Aldolase) as well as ATP in skeletal muscle with ischemia. In regions in which PtO2 max was below 10 mmHg, ischemic changes in the muscle were considered irreversible. Probably an elevated IHb and a decreased ISO2 indicate a worse prognosis. Blood flow is decreased in the mild subgroup, compared to the normal group, with a decline in IHb and a milder decrease in ISO2 than in the severe subgroup due to a less severe obstruction to blood flow. Absence of a significant difference between the diseased and normal groups may be explained by a decrease in blood flow with hemostasis resulting in low and high IHb values, respectively, which results in mean values which are not significantly different.

Mitochondrial oxidative phosphorylation is halted during muscle ischemia, resulting in deficient energy and changes in the biochemical environment such as pH values and ion concentrations. Disturbance in the contractile function...
of muscle appears first. This occurs within 6-8 hours of onset of acute ischemia, followed by structural decay and further morphological changes (Yazaki and Yamaoki, 1984). The time from onset is important in the evaluation of prognosis in ischemic limbs. But, evaluation based on time alone is difficult, especially in veno-occlusive diseases and chronic obstructive diseases. Taken together with the general condition of the patient and the extent of the blood flow interruption, measurement of hemodynamics using the tissue reflection spectrophotometer would provide useful information for prognosis of the ischemic limb. Although the present data is preliminary and further experience will be necessary to confirm these findings, we conclude from the present study that conservative treatment or thrombectomy was indicated when both the IHb and ISO2 values were decreased in comparison to the non affected foot. However, an elevated IHb and a decreased ISO2 indicate a worse prognosis and amputation of the limb should be considered initially.

References


