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Myoglobin release after tourniquet ischemia

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The concentration of myoglobin in plasma was assessed before and up to 68 hours after tourniquet release in 27 patients who underwent elective operations with no incision into skeletal muscle. The duration of ischemia was 1–3 hours. A control group underwent the same kind of surgery without the use of tourniquet. There was a minimal elevation in myoglobin values after 65 and 90 minutes of ischemia, and a marked elevation after more than 150 minutes of ischemia. Maximum values were reached 8 to 10 hours after tourniquet release, and preoperative values after 50 to 60 hours.

The duration of an ischemic period is a crucial factor for muscle cell damage (Paletta et al. 1960), but opinions still differ as to the critical time limit for application of tourniquet, before signs of cell damage occur (Klenerman 1980). The release of intracellular proteins is considered to be the earliest sign of ischemic muscle cell damage (Newman 1984, Chiu et al. 1976) because after prolonged periods of anoxia, larger molecules such as myoglobin and enzymes will leak through the membrane.

I report the effect of tourniquet ischemia on myoglobin concentration in plasma and the influence of ischemic time.

Patients and methods

Twenty-seven patients underwent elective operations: knee prosthesis, meniscectomies, synovectomies of the knee, arthroscopy with lateral release. None had muscular diseases or evidence of ischemic changes in the limb. The median age was 67 (18–84) years, and there were 8 males and 19 females. Nine patients had rheumatoid arthritis, never treated with steroids.

A tourniquet of the Kidde type around the thigh was inflated to 6 kPa (450 mm Hg) after 10 min of limb elevation. After each hour of ischemia, there was a 10-min period for recirculation of the limb. The patients were subdivided according to the duration of ischemia in groups with an exact duration of 65 min (n 4), 90 min (n 5), 150–170 min (n 5), and 180 min (n 1).

A group of 5 patients (2 males and 3 females) who underwent the same kind of surgery without use of bloodless field were used for comparison.

The assay of myoglobin was based on a radioimmuno assay (Hansen and Nørregaard-Pedersen 1980). The normal upper limit for the myoglobin content in plasma by this method was 75 μg/L.

The Spearman ranked sum correlation test and the Mann-Whitney test were used.

Results

The preoperative values of myoglobin were below 75 μg/L in 20 cases, but slightly elevated in 7 with median 91 (77–120) μg/L. All in the control group had below 75 μg/L.

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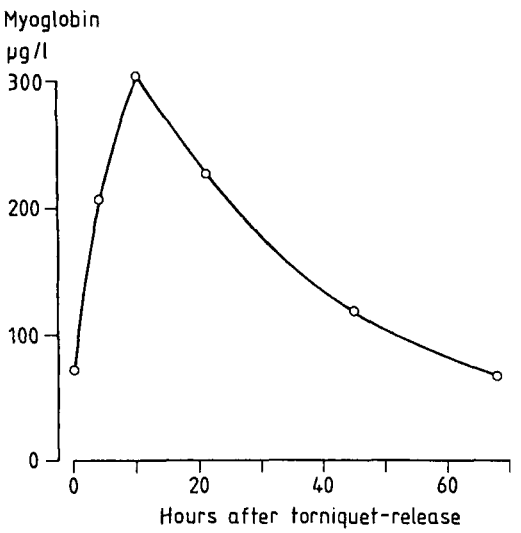

Figure 1. Typical course of the myoglobin concentration in plasma after use of tourniquet in a 72-year-old woman for 115 minutes.

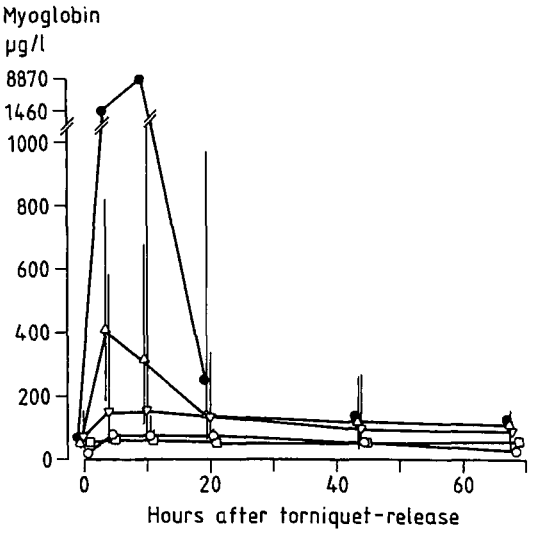

Figure 2. Median concentration in plasma in patients with tourniquet times of 65 minutes (n 4), 90 min ▽ (n 5), 150–170 min △ (n 5), 180 min • (n 1), and a control group ▽ (n 5) without use of tourniquet.

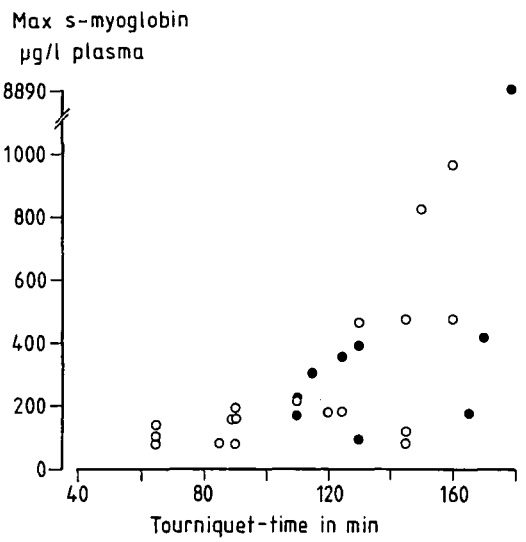

Figure 3. Peak values of myoglobin in plasma and tourniquet time in 27 patients.
• Preoperative concentration slightly elevated.
o Preoperative concentration within normal range.

After release of the tourniquet, an initial increase in the myoglobin concentration was followed by a gradual decrease. The peak value was found 4 to 10 hours after release. After 68 hours the myoglobin had fallen to a preoperative or slightly elevated level (Figure 1).

The control group showed no postoperative changes in myoglobin plasma concentration.

There was a small rise in myoglobin concentration in patients with a tourniquet duration of 65 minutes and also in patients with 90 minutes, where the maximum myoglobin concentration medians were respectively 98 (74–139) µg/L and 154 (71–150) µg/L, which were followed by a fall to preoperative values after 68 hours (Figure 2).

There were no differences in peak values between the control group and patients with a tourniquet duration of 65 and 90 minutes.

Patients with a tourniquet duration of 150–170 minutes had pronounced initial increases in myoglobin concentration with wide ranges in the peak values; median 411 (189–970) µg/L, different from the control group and the groups with 65 and 90 minutes of tourniquet time ($P < 0.01$).

Discussion

In a study carried out on the rhesus monkey, Patterson (1979) found that the histologic changes in the muscle lying immediately under the cuff of the tourniquet were slightly more pronounced than those observed in muscles distal to the cuff. In contrast, Dahlbäck (1970) found that degenerative muscle changes appeared to be largely disseminated in the muscle; the motor end plates were sensitive to tourniquet ischemia.

The appearance-disappearance of myoglobin

concentration has been studied previously in myocardial ischemia. Sylven & Bendz (1978) found that after acute myocardial infarction, peak levels of myoglobin in serum were found after 9.4 hours with a higher magnitude and a quicker disappearance than in my study. Bomfim et al. (1980) found that myoglobin concentration peaked during the first 4 hours after release of aortic cross-clamping after hypothermic cardioplegia.

The effect of cooling prior to tourniquet application is well known (Paletta et al 1960), and Nakahara (1984) demonstrated that the underlying mechanism is a more effective restoration of microcirculation after prolonged ischemia.

My observation that the disappearance in myoglobin concentration was of longer duration than in myocardial infarction or ischemia can be explained by the influence of postischemic edema on microcirculation in the limb (Edfeldt & Thomson 1980, Miller et al. 1979, Klenermann et al. 1982); edema, increased interstitial pressure, and arteriovenous shunts may cause alteration in muscle cells. The duration of edema can be as long as 20 hours (Silver et al. 1986), and leakage of larger proteins as creatine kinase through muscle membranes can persist up to the third day after blood flow is restored (Presta & Ragnotti 1981).

Several studies have shown that metabolic changes after 2 to 3 hours of induced ischemia are reversible in human musculature (Häggmark 1981, Newman 1986), and this duration seems to be safe for the skeletal muscle (Klenermann 1980).

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