TISSUE BLOOD EXCHANGE AND TISSUE OXYGEN TENSION IN RELATION TO TOTAL BODY OXYGEN CONSUMPTION IN EXPERIMENTAL SURGICAL SHOCK

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The purpose of this work was to study blood to tissue exchange by both flow and diffusion in skeletal muscle and to relate these local tissue variables to total body oxygen consumption in an intestinal shock model in dogs. Furthermore this shock model was used to evaluate the effectiveness and duration of different plasma substitutes in counteracting the experimental surgical shock.

MATERIALS AND METHODS

Sixty dogs were anaesthetised with ketamine chloride and pancurium bromide and ventilated on air. After appropriate cannulation the animal was allowed to stabilise and control measurements were made. Splenectomy was then performed (duration 20 min) and the small intestine was exteriorised for three hours. During this time the dogs developed hypovolaemia to 65% plasma volume, haemoconcentration (haematocrit = 59%) and a fall in arterial blood pressure to 95 mmHg. Measurements of muscle blood flow PO2 and oxygen consumption were made before the intestines were replaced. The effects of infusion of different plasma substitutes were investigated after replacement of the intestines within the abdomen. A single infusion of 20 min. duration was given and measurements were made after 1, 2 and 4 hours. The colloids (Dextran 40) were given in a dose of 1.5 g/kg body weight in a 3.5% solution. Ringer's acetate was given in a volume 3 times that of the colloid solutions.

Muscle capillary blood flow and diffusion capacity was measured during the radioactive isotope clearance technique described by Appelgren. The diffusion capacity in skeletal muscle was expressed as a PS-value, which is a product of capillary permeability (P) and the capillary area open to metabolic exchange (S). Muscle tissue
oxygen tension was measured with a PO$_2$-electrode inserted into the muscles. The total body oxygen consumption was measured continuously according to Guyton.

RESULTS

Fig. 1A shows the muscle blood flow ($Q_{xe}$) expressed in ml blood/min/100 g tissue, in relation to the PS-value (ml plasma/min/100 g tissue). The position for each single dog is marked in the control and in the shock situation. The lines around the control and shock states were drawn by hand to separate these two states. There is practically no overlap between control and shock in respect of the PS-value. The muscle blood flow decreased in shock as compared to the control. However there was a marked overlap in values between control and shock.

Fig. 1B shows that muscle PO$_2$ was higher in the control situation compared with that during shock. The total body oxygen consumption during control and shock situations was also clearly separated as is seen in Fig. 1C.

In order to assess the results statistically a computer analysis was performed on the means, standard deviations and the regression coefficients for all observations in control and shock for all sixty dogs.

Fig. 1D, E, F shows the result of computer analysis. The triangle is the mean of all sixty animals in the control situation and the black dot the mean in shock. The ellipses drawn around the means represent one standard deviation from the mean and the slope of the ellipse is due to the regression coefficient. Fig. 1D shows the PS-value, Fig. 1E the muscle oxygen tension, and Fig. 1F total body oxygen consumption, all in relation to the muscle blood flow.

The effects of infusion of Dextran or Ringer in the shocked animals can be assessed by a similar type of statistical analysis.

Fig. 2 shows the relationship between muscle oxygen tension and blood flow in the different groups of animals. Fig. 2A shows the results of 8 untreated animals. The ellipses represent all 60 animals in control and shock. The black triangle and the black dot are now the means for the 8 untreated animals in control and shock respectively. The circles with figures inside represent the means of these 8 animals, 1, 2 and 4 hours after replacement of the intestine. Untreated animals remained in the shock area for at least 4 hours. The total body oxygen consumption and the PS-value in the untreated group did not improve either.