The Influence of Anaemia on Cardiopulmonary Function during Exercise in Patients Undergoing Haemodialysis Treatment

D STRANGFELD, E EICHHORST, D LUCAS, H SIEWERT, W DUTZ, K BUCHALI, K PRECHT, K H GÜNThER, G ANDERS

II Medical Clinic of Humboldt University and Krankenhaus im Friedrichshain, Berlin, German Democratic Republic

Patients with chronic uraemia on regular haemodialysis treatment are commonly affected by more or less severe anaemia. Attempts to stimulate red cell production using drugs are ineffective. However, large blood transfusions should be avoided because of the possibility of renal transplantation and the risks of hepatitis and haemosiderosis.

Recently, the opinion has spread that the infusion of one unit of blood per month or even less would be sufficient for life, keeping the haemoglobin content within the range of 4 to 8 g/100 ml. In this country patients usually receive 0 to 2 units packed red blood cells per month. In these cases the haematocrit varies from 12 to 20%. On the other hand, with a haematocrit below 16%, troubles like headache, general weakness, and exertional dyspnocia are often observed.

METHODS

In this study the following methods were used before and during standardised exercise: measurements of cardiac output (radiocardiography), heart rate (ECG), electromechanical systole (phonocardiography), arterial cuff blood pressures, tidal volume (per minute), and pulmonary diffusion capacity. The 9 patients examined had no clinical sign of congestive heart failure; yet, after walking to the third floor all had severe dyspnocia and a prolonged recovery period.

The exercise was performed using a Godard cycle-ergometer at the 20 and 50 watt level. Before, during and after exercise the cuff blood pressure and the heart rate were recorded together with the total systole every minute. Cardiac output stroke volume and total blood volume were investigated simultaneously by injection of 7 μCi radio-iodinated human serum albumin (RIHSA) prior to the onset of exercise and during the 6th minute after beginning.

All cases were normotensive without hypotensive treatment. Haematocrits were in the range 12 to 19%. Urea-nitrogen before haemodialysis was
Figure 1. Blood pressure and heart rate at rest during exercise and at the recovery period. Pulse rate and blood pressure are significantly increased during exercise in patients with low haematocrit (black line). The recovery period is prolonged and becomes normal after increasing the haematocrit (broken line).

Figure 2. Behaviour of heart rate, blood pressure, tidal volume per minute and cardiac output, before and after increasing the haematocrit. The shaded area represents the normal control group. The columns show the amount and direction of the changes before and after increase of the haematocrit.
about 90 mg/100 ml or lower. Total blood volume, blood pH, Pco₂ and PaO₂ were normal. Ten to fourteen days after transfusion leading to an increase of the haematocrit to 22 or 30% (mean 25), the urea nitrogen, blood pressure and total blood volume were unchanged.

RESULTS

The heart rate at rest decreased considerably ($p<0.05$) after improvement of the anaemia. During exercise (25 to 50 watt, Figures 1 and 2) it increased significantly to about 130 beats per minute (6th minute) before treatment and returned to normal when the haematocrit reached 22% after red cell infusion. The recovery period was prolonged before treatment; 10 minutes after starting the exercise the difference between pre and post treatments levels was even greater.

The systolic and diastolic cuff pressures at rest were normal (Figures 1 and 2). The increase of the systolic pressure during exercise, however, was significantly higher than that found in a control group investigated previously. After improvement of the haematocrit the systolic pressure was significantly lower during exercise.

The cardiac output was somewhat diminished after blood transfusion (Figure 2), but at rest and during exercise it was significantly higher than in normal subjects.

Figure 3. Relation between electromechanical systole adjusted for the heart rate and the reciprocal value of the ejection resistance. After an increase of the haematocrit it tended to be normal at rest and during exercise
The total systole adjusted to heart rate (Q-IIA/HR) — which may be an indirect measure of the ventricular volume — showed a significant prolongation after blood transfusion (during exercise) whereas the systolic ejection resistance remained constant (Figure 3).

Tidal volume per minute \( (V_t_{min}) \) (Figure 2) decreased at rest and during exercise after increase of the haematocrit, but in comparison with the normal control group all values varied within the normal range. On the other hand, the pulmonary diffusion capacity increased significantly after the rise in haematocrit.

**DISCUSSION**

The results suggest that patients with chronic uraemia and severe anaemia (haematocrit 12 to 19%) have a reduced adaptability even to moderate exercise. By comparison with our normal control group their physical working capacity (PWC) is diminished but can be improved by an increase of the haematocrit to 22 or 30%. Heart rate, blood pressure and tidal volume are within normal limits at rest, whereas the cardiac output is abnormally high. According to Lüthy (1962) the haemodynamic situation of these patients does not indicate any impairment of cardiac function. At rest and during exercise the cardiac output is high, corresponding with the hyperkinetic circulation which tends towards normal after blood transfusion. None of these cases showed criteria which have to be interpreted as due to heart failure. Thus, it may be concluded that normotensive patients with chronic uraemia and severe anaemia in a regular haemodialysis programme commonly have a diminished physical working capacity, particularly when the haematocrit level is below 16%. This disturbance can be partially compensated by the heart and circulation. This regulation is shown by the changes of the heart rate, systolic blood pressure and the exertion dyspnoea during moderate exercise.

**REFERENCE**

Lüthy, E. (1962) Bibliotheca cardiologica (Basel), 11
OPEN DISCUSSION

L MIGONE (Chairman): I would like to ask if you have studied the relationship between muscular exercise and oxygen consumption; as you know in the normal condition there is a point at which there is a shift from aerobic to anaerobic work. Was this point changed in uraemic patients compared to normal subjects at the same haemoglobin level? Can you measure this?

STRANGFELD: We couldn't find any changes in their acid base balance; we have studied pH and Pco₂ and also acid base balance, and we couldn't find any changes in the normal group or in the uraemic groups — all had normal values. Even in those we have called decompensated, we could find no changes in acid base balance. Pulse rate and blood pressure were higher and the patients couldn't work at the higher level; they could only work over a period of six minutes, or only half this period of six minutes at 50 watt, and could not work at all at 100 watt. Even so, we couldn't find any changes in their acid base balance.