THE EFFECT OF EXTRACORPOREAL HAEMODIALYSIS ON ENERGY TURNOVER

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Summary

The effect of haemodialysis on energy turnover (Q_{tot}=Q_{rcc}+Q_{evap}) was measured by a metabolic scale (Q_{evap}=evaporative heat loss) and by nine thermistors placed on the skin surface, rectally and exposed to ambient room temperature (Q_{rcc}=radiant, convective and conductive heat loss). The energy turnover values after haemodialysis in all 13 patients with end-stage renal disease were higher than those measured prior to dialysis. The initial values for Q_{tot}, Q_{rcc} and Q_{evap} were 28.9±3.1, 22.7±3.0 and 6.3±0.8kcal/kg/day respectively. After haemodialysis 31.4±3.5, 24.5±3.3 and 7.0±1.0kcal/kg/day for Q_{tot}, Q_{rcc} and Q_{evap} respectively were obtained. The increase of 2.5kcal/kg/day for Q_{tot} was significant ($p<0.05$).

Introduction

Haemodialysis interferes with body fluid composition and with fluid volume regulation. Therefore changes may occur in energy turnover during haemodialysis and therefore resting metabolic rate was assessed before and after dialysis by measuring the total loss of heat (Q_{tot}). Q_{tot} is the sum of heat loss due to evaporation (Q_{evap}), radiation, conduction and convection (Q_{rcc}). These were measured and calculated by using a metabolic scale (Q_{evap}) and several thermistors on line with a temperature computer for the determination of the skin surface temperature [1].

Patients and methods

Thirteen patients (7 females, 6 males) with end-stage renal disease (C_{creat} <2.0ml/min) were investigated. The mean age was 62.2±10.2 years. The underlying kidney disease was glomerulonephritis (8), polycystic kidney disease (2), obstructive pyelonephritis (2), analgesic nephropathy (1) and diabetic nephropathy (1). Mean duration on dialysis was 16.5±26.2 months. The period dialysis ranged from 2.75 to 4.0 hours, three times weekly. Hollow fibre kidneys (SMAD 100–2, GF 120 M) were used. After a priming dose of 2.500 IU heparin was infused continuously with 500 to 1.000 IU/hour. The ultrafiltration was 0.96±0.41 (r=0.3–2.0) kg/dialysis. The dialysate temperature was 37°C. Acetate (35mM/kg) was used as buffer in the dialysis solution.

Energy turnover was determined before and after the regularly performed dialysis. A resting period of 30 minutes supine under the environmental climatic conditions of the measurement preceded each determination. No food intake occurred between the two determination periods, each of which lasted 30 minutes. The heat loss was measured under normal conditions with continuously controlled room temperature (before and after dialysis 24.5±0.0°C and 24.8±0.9°C respectively) and air humidity (47±5% and 50±7% before and after dialysis respectively). The air velocity was less than 10cm/sec. During the resting period as well as during the measuring period the unclothed patients were confined to the metabolic scale.

The Q_{rcc} was determined with seven thermistors placed on various representative areas of the skin surface. The skin mean temperature was then calculated using the weighting factors described by Hardy and DuBois [2]. The skin mean temperature forms with the simultaneously registered room temperature (8th thermistor) a difference (ΔT) which, by using a summarized thermodynamic formula of heat exchange (including radiation – Stefan Boltzmann – as well as conduction and convection) leads to an expression of heat loss given by the equation $Q_{rcc}=H \times F_S \times \Delta T$. The heat transfer coefficient (H) was determined previously under identical environmental conditions using the method of indirect calorimetry [1]. The body core temperature was measured continuously by a ninth thermistor located on the tip of a rectal temperature probe which was inserted to a depth of at least 10cm. The sensitivity of the temperature measurement by these thermistors was 0.01°C.

The weight loss of the patients was determined by the metabolic scale simultaneously with the temperature measurements. The accuracy of the rate of weight loss was ±1.0g/hour. The sensitivity of the scale amounted to 0.1g. The weight loss was registered continuously on a recorder. It is due to the evaporation of water, which requires 0.58kcal/g (Q_{evap}).

Thus the total heat exchange (Q_{tot}) finally is given as:

$$Q_{tot} = Q_{rcc} + Q_{evap}$$

Statistical evaluation was performed with Student's 't' test after a normal distribution of values was shown to exist.

Results

In Table I Q_{tot} (kcal/kg/day) of all 13 patients before and immediately after extracorporeal haemodialysis is shown.

In all subjects an increase of energy turnover was observed. The mean energy turnover per kg body weight of all 13 patients before haemodialysis was Q_{tot} = 28.9±3.1kcal/kg/day. After haemodialysis their energy turnover had

TABLE I. Heat loss (Q_{tot}) of 13 patients with end-stage renal disease given in kcal/kg/day immediately before and after haemodialysis (HD)

Patient	Q_{tot} (kcal/kg/day) Before HD	After HD
1	34.04	36.20
2	27.52	29.52
3	28.36	29.45
4	30.58	34.75
5	28.28	29.72
6	34.66	39.82
7	25.30	29.53
8	26.58	29.17
9	29.41	31.26
10	28.78	28.76
11	27.35	32.48
12	26.30	27.35
13	25.29	33.82
M($\bar{m}$,s)	28.9±3.1	31.4±3.5
	$p<0.05$	

risen to Q_{tot}=31.4±3.5kcal/kg/day. Thus the heat exchange rate after dialysis was significantly increased by 2.5kcal/kg/day on the average, representing 8.7 per cent of the mean initial value ($p<0.05$).

The behaviour of Q_{rcc} and Q_{evap} as compared to Q_{tot} is shown in Table II.

TABLE II. Mean values of heat loss (Q_{tot}) due to evaporation (Q_{evap}), radiation and convection (Q_{rcc}) in 13 patients before and after haemodialysis (HD)

	Energy expenditure (kcal/kg/day) Before HD	After HD	
Q_{evap}	6.3±0.8	7.0±1.0	+ 11.1%
Q_{rcc}	22.7±3.0	24.5±3.3	+ 7.9%
Q_{tot}	28.9±3.1	31.4±3.5	+ 8.7%

The evaporation heat loss was increased after haemodialysis by 11.1 per cent of the initial value whereas the radiant and convective heat loss after haemodialysis was 7.9 per cent above that prior to dialysis.

The body core temperature rose in all 13 patients during haemodialysis. It was 36.2±0.5°C on the average prior to dialysis and increased to a mean value of 36.8±0.4°C after haemodialysis ($p<0.05$).

In Table III the skin temperatures before and after haemodialysis are shown.

In all patients the temperatures at the various locations on the skin surface after dialysis were higher than before dialysis. The largest differences were obtained at the back of the hand and at the back of the foot with ΔT=1.5± 2.3°C and 2.0±1.9°C respectively.

TABLE III. Skin temperatures at various locations measured by thermistors. Mean values of 13 patients before and after haemodialysis

	Skin temperature		
	before dialysis	ΔT	after dialysis
cheek	33.6°C±1.1	0.8°C±1.6	34.0°C±1.1
sternum	33.2°C±0.7	0.5°C±0.9	33.7°C±0.5
upper arm	32.2°C±1.1	0.6°C±1.5	32.8°C±1.1
back of hand	30.9°C±1.7	1.5°C±2.3	32.4°C±1.5
thigh	31.5°C±0.5	0.8°C±1.0	32.2°C±0.8
lower leg	31.2°C±0.7	0.7°C±1.0	32.0°C±0.7
back of foot	30.1°C±1.5	2.0°C±1.9	32.0°C±1.1

Discussion

The heat loss of 13 patients with end-stage renal disease before dialysis (Table I) was slightly elevated compared with normal healthy volunteers in whom Q_{tot}, Q_{rcc} and Q_{evap} were 26.6±3.5, 24.5±2.5 and 6.6±1.0kcal/kg/day respectively. This difference however was statistically not significant, mainly due to the small number of only seven healthy subjects in the control group. The nevertheless slightly elevated rate of energy production in the dialysis patients before dialysis might be due to the fact that in contrast to the normal subjects who were under basal metabolic conditions the haemodialysis group was investigated only under resting conditions.

A markedly higher heat loss was obtained in all 13 patients immediately after haemodialysis when compared with the heat loss before dialysis. The heat exchange was increased on the average by at least 8.7 per cent of the initial values prior to dialysis. Since both the mean skin temperature as well as the core temperature were higher after haemodialysis, the heat content of the total body must have been increased. The heat production under haemodialysis therefore, is even slightly higher than that estimated by the total heat loss (Q_{evap} + Q_{rcc}). An increase of the heat content of the body by an increased ambient room temperature between the two measurements has been excluded as well as heat gain by the dialysate temperature.

These data show that an increased heat production seems to occur during haemodialysis. The reason for the increased heat production is unknown. Simultaneous measurements of thyroid hormones in these patients showed no consistent trend. Aldosterone concentration decreased slightly during dialysis; the concentration of cortisol increased slightly.

Since during acetate-dialysis 40.3±4.8 per cent of the total carbon dioxide output has been shown to be due to the oxidation of acetate [3] a thermogenetic effect of acetate must be considered. The decrease in peripheral resistance under acetate dialysis [4–6] is parallel with the increase of skin temperature observed in our patients. An increase in energy production of the same order of magnitude, however, was observed also during peritoneal dialysis in which no acetate was used.

References

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