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EXTRACELLULAR VOLUME AND BLOOD PRESSURE IN 82 HAEMODIALYSED CHILDREN

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Summary

Inulin distribution volume was analysed in 82 children, 17 months to 18 years old, on regular haemodialysis. A 'normal' inulin distribution volume range was reported in normotensive haemodialysed children. Significant increase was found in hypertensive children when hypertension was not controlled. Inulin distribution volume was significantly decreased in children who had intolerance signs, such as hypotension, during dialysis, whatever the blood pressure. In our experience, inulin distribution volume determination can help the management of hyper- or hypotension problems frequently observed in children on dialysis.

Introduction

Clinical evaluation may fail to detect extracellular fluid (ECF) volume disturbances in haemodialysed children. In these patients whose weight can increase with growth or decrease with intercurrent diseases, it is important to measure ECF volume, and determine the 'dry weight'. ECF determination permits on the one hand evaluation of one of the mechanisms of hypertension, i.e. overhydration and on the other hand to detect chronic dehydration with its frequent complication, i.e. hypotension during dialysis. There are few published reports on ECF volume in haemodialysed children [1–3]. In these studies, ECF expansion was found as in haemodialysed adults, whatever the ECF tracer used as radioactive sulphate or sodium [4–7] and less frequently stable bromide or inulin [7,8]. As repetitive determinations have sometimes to be performed in young children during haemodialysis and perhaps in future adult life, we have chosen inulin, a convenient non-radioactive tracer. In our department, inulin distribution volume has been measured as a *routine* parameter since 1977. In this study, we report 108 inulin distribution volume results performed in a population of 82 haemodialysed children between 1979 and 1983. We have determined a 'normal' range and related values to the arterial pressure status (hyper- or hypotension) observed.

Patients and methods

Eighty-two haemodialysed children between the ages of 17 months to 18 years (mean 10.4±3.9 years, SD) had 108 ECF determinations. The causes of renal disease are detailed in Table I. Eleven children were surgically anephric. They

TABLE I. Primary renal diseases in patients

	Number of children	Number of anephric children
Glomerular diseases	25	2
Uropathy ± dysplasia	14	3
Heredo familial disease		
medullary cystic disease (nephronophtisis)	8	1
other cystic kidney disease	1	
Alport's syndrome	3	1
cystinosis	6	
oxalosis	2	
Bartter's syndrome	1	1
Renal hypoplasia	10	
Haemolytic uraemic syndrome	3	1
Miscellaneous	9	2

had regular haemodialysis in hospital or in the home, three times a week in 71 cases, twice a week in 31 cases and once a week in two children with residual renal function. The period on haemodialysis varied from two weeks to seven years. Dialysis fluid had a Na^+ concentration of 145mM/L. Acetate dialysate was used in 90 cases and bicarbonate in 18 cases.

These children have been subdivided into four groups: Group I was composed of 45 normotensive children; in this group, 31 studies have been obtained in children who had no intolerance signs during dialysis, such as hypotension, nausea or vomiting (Group Ia) and 14 children with intolerance signs noted at least once during the four last consecutive haemodialyses (Group Ib). Group Ia was our reference group.

Sixty-three ECF determinations were performed in hypertensive children: 14 in children with no hypotensive drugs (Group II), 29 in children with high blood pressure in spite of hypotensive therapy (hydralazine, β-blockers, captopril, nifedipine) in Group III and 20 in treated children with normal blood pressure (Group IV): 16 had no intolerance signs as previously defined (Group IVa) and four had signs (Group IVb).

ECF volume has been measured between two dialysis periods as inulin distribution volume. A 10% inulin solution (0.5ml/kg body weight) has been injected intravenously as a bolus. Blood was sampled before and 120, 180, 210 and 240 minutes after the injection. At these times, equilibrium was always achieved and the mean of these values was used to calculate inulin distribution volume.

Inulin concentration in samples was determined as previously described [9]. Inulin distribution volume was expressed as percent of body weight (% b.w.). Mean and standard deviation (SD) have been calculated in each group. Student's 't' test has been used to compare mean values of the different groups with Group Ia.

Results

Mean inulin distribution volume values in the different groups are summarized in Table II. In Group Ia, ECF ranged between 22 and 29 per cent body weight. Group Ib differed significantly from Ia ($p<0.001$, range 15.5–22% b.w.). Inulin distribution volume was significantly increased in Group II ($p<0.001$, range 27.5–40.1% b.w.) and in Group III (range 18.2–41% b.w.) while inulin distribution volume was significantly decreased (range 20.8–27%) in children whose blood pressure was normal with therapy (Group IVa). Intolerance signs to dialysis were constantly observed in children with inulin distribution volume values <22 per cent body weight and hypertension between dialyses when inulin distribution volume was >29 per cent body weight.

TABLE II. Inulin distribution volume (IDV) in haemodialysed children. Group Ia, normotensive children without intolerance signs was the reference group

Group	Ia	Ib	II	III	IVa	IVb
n	31	14	14	29	16	4
IDV (% body weight)	25.2	19.9	32	30.6	23.8	18.3
SD	1.8	2.3	4.0	5.5	2.1	1.3
p		***	***	**	**	

*** $p<0.001$; ** $p<0.02$

TABLE III. Evolution of arterial blood pressure (systolic and diastolic), weight and inulin distribution volume in a child during a 39 month (m) dialysis period before and after bilateral nephrectomy

	Before bilateral nephrectomy			After bilateral nephrectomy	
	TO	1m	18m	34m	39m
Weight (kg)	28.300	26	27	27.300	29.6
Height (cm)	132	132	133	134	136
Arterial blood pressure (mmHg)	220–160	140–100	150–110	150- 120	130–60
IDV (% body weight)	41	22.5	21	34	19.5
IS	0	0	+	0	+
Therapy	Hydralazine Acebutolol	Hydralazine Acebutolol	Captopril	Nifedipine Labetalol	0

Table III illustrates a demonstrative case. Five consecutive inulin distribution volume determinations were performed. Hypertension appeared early at the beginning of haemodialysis treatment when the inulin distribution volume value was high. Reduction of inulin distribution volume associated with hypotensive drugs failed to reduce hypertension and bilateral nephrectomy had to be performed. A normal blood pressure was then obtained while inulin distribution volume was in the normal range.

Discussion

In adult or in young haemodialysis patients, ECF volume estimation frequently reveals an increase above normal whether the measurements are related to actual body weight or to fat-free weight. Nevertheless, ECF expansion can exist in some haemodialysis subjects without increased arterial blood pressure or, in some other subjects, can induce or increase hypertension. So it was important to determine the inulin distribution volume range of normotensive children on regular haemodialysis. The large 'normal' inulin distribution volume scatter (22 to 29% b.w.) could be due to differences in the child's nutritional status, not evaluated here, or more likely to differences in cardiovascular tolerance to ECV expansion. In our experience inulin distribution volume values higher than 29 per cent body weight were always associated with high blood pressure. So in newly hypertensive subjects, reducing dry weight under this limit is generally the first therapy used prior to the administration of hypotensive drugs. Moreover, hypotensive drugs were efficient only in children with 'normalized' or low inulin distribution volume values.

Intolerance signs during dialysis are certainly related not only to the amount of ultrafiltrate subtracted during haemodialysis treatment, but also to the rate at which the removal occurs [10]. Nevertheless, in our study, these symptoms were closely related to the inulin distribution volume determined *between* two dialyses. They were constantly observed when inulin distribution volume was less than 22 per cent body weight whatever the dialysis bath composition (bicarbonate or acetate).

In conclusion, routine ECF measurement appears to be a useful determination in haemodialysis children. This easy to perform determination can help the paediatricians to manage arterial blood pressure problems often encountered in these children.

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