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Serum Electrolytes and Urea in Healthy Nigerian Children

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Effiong, C. E., Aderele, W. I., Akinkunmi, A. and Ayeni, O. (1974) *Nigerian Journal of Paediatrics*, 1 (1), 3. **Serum Electrolytes and Urea in Healthy Nigerian Children.** The results of serum electrolytes and urea determined in 233 healthy Nigerian children aged from birth to 11 years and in 40 cord-blood specimens are presented.

Generally, serum electrolytes levels in this study were, significatly higher than the levels recently reported in Nigerians and lower than those for North American children.

While sodium values in neonates, infants and older children were similar, these were significantly lower than in cord-blood specimens. Chlorides were similar in all age groups; potassium levels were high and decreased with age, and bicarbonate levels increased with age up to 1 month. There were no significant differences in any of the electrolytes components between the sexes or ages after the neonatal period.

DIARRHOEA is one of the commonest reasons for paediatric consultation or hospitalisation of children throughout developing countries in the tropics (Effiong and Antia, 1971). Severe dehydration and electrolyte derangements which accompany severe diarrhoea can only be effectively managed by intravenous infusion of appropriate solutions. To achieve effective rehydration, an accurate knowledge of normal electrolyte values in different age groups is essential.

Previous studies on electrolytes from the University College Hospital (U.C.H.) Ibadan concerned either adults and children (McFarlane *et al.* (1970) or adults alone (Edozien 1958). The only study of electrolytes from this institution which concerned children alone (Hendrickse,R.G., personal communication) has not been published. Since the values obtained by the above authors are contradictory, the present study was undertaken to see how values in healthy Nigerian children compare with:

(1) previous reports from this institution and
(2) reports from the temperate regions.

Materials and Methods

The present study was carried out during a five-month period (August to December, 1972). Subjects for the study were healthy Nigerian children from:

(*a*) UCH—out-patients clinics, elective surgical cases, and neonates in the lying-in-wards;

(*b*) IBADAN HOME FOR MOTHERLESS BABIES;

(*c*) CATHOLIC HOSPITAL, OKE-OFFA, Ibadan—neonates in the lying-in-wards.

Also included in the study were cord-blood specimens obtained from the foetal surface of the placentae through an umbilical vein soon after normal delivery.

Selection of Subjects

Before each subject was admitted to the study, there was a clinical evaluation with particular attention paid to history of diarrhoea and vomiting, fever or any other illness which could cause electrolyte derangement. The father's occupation was noted as a means of assessing the child's social class. Children with fever, oedema, dehydration, hypertension and weight less than 70 per cent of the average expected for age and sex, were excluded from the study. Also excluded were those with Haemoglobin (Hb) genotype S.

Procedure of blood collection

Blood specimens were obtained by peripheral venepuncture. In order to avoid mechanical lysis, the needle was removed from the syringe before the specimen was placed in a tube containing liquid paraffin for electrolyte estimation. Blood for Packed Cell Volume (PCV), Haemoglobin genotype and for malarial parasites, was collected in a sequestrine tube.

Laboratory procedures

Serum electrolytes and urea were determined in the paediatric research laboratory within 6 hours of blood collection. Serum sodium and potassium were estimated by standard flame photometry; chloride by Buchler-Cotlove chloridometer; bicarbonate by means of Natelson microgasometer and urea by Urease Nesslerization (Varley 1962).

Laboratory quality control

'Versatol Pediatric' and 'Versatol' (General Diagnostic Department, William R. Warner & Co. Ltd, Eastleigh, Hampshire, U.K.) were used as quality control. 'Versatol Pediatrics' was used as control for estimation of sodium, potassium, chloride and urea for cord-blood specimens, and for blood obtained from babies aged one to five days. For children above the age of five days 'Versatol' was used. The control-dried serum was reconstituted each time as directed by the manufacturers; the electrolyte content was determined and compared with values given by the manufacturers. It was only when the results obtained were within ± 5% of values supplied by the manufacturers, that the test specimens were analyzed in exactly the same way as for the control specimen. It was not, however, possible to use reconstituted dried sera as control for bicarbonate estimation.

Results

Serum electrolytes were estimated in 273 blood specimens obtained from 40 placentae, 32 neonates and 201 children. Table I shows the age and sex distribution of subjects. One hundred and thirty-three (49 per cent) specimens were collected from children aged 1 month to 3 years. There were 140 males and 93 females. The occupations of the fathers of 179 children were determined. Of these 33 were professionals, 49 clerks, 51 semi-skilled (lorry or taxi-cab drivers, fitters and motor mechanics), while 43 were labourers and only 3 unemployed. The distribution of Hb. genotype in 192 specimens

TABLE 1

Age and Sex Distribution of Subjects

Age Range	*Male*	*Female*	*Total*
Neonates	18	14	32
1 mon–1 year	36	23	59
Year 1 – 3	47	27	74
,, 3 – 7	19	15	34
,, 7 11	20	14	34
Total	140	93	233

was 150 AA, 35 AS and 7 AC. Of 15 children with malarial parasitaemia, 5 had heavy infection without clinical manifestations. The average PCV value varied with age (49 per cent for cord-blood specimens and in neonates; 31 per cent for 1–6 months; 34 per cent for 6 months to three years and 38 per cent for three to eleven years age groups). The PCV range for the corresponding groups were 38–63 per cent for cord-blood and neonates; 27–37 per cent for 1–6 months; 25–43 per cent for six months to three years and 25–48 per cent for three to eleven years.

Electrolytes and Urea

Sex, social class, Hb. electrophoretic pattern and PCV levels had no significant influence on serum electrolytes and urea values. Similarly, after the neonatal period (Table II), the values did not vary significantly with age.

Serum sodium

Serum sodium levels were similar in all the children from birth to eleven years of age (Table III). Cord blood levels were however, significantly higher ($P<0.001$) than levels for children aged one month to eleven years. The sodium levels in the present study (Tables IV and V) show a significantly higher cord-blood value ($P<0.001$) than those reported by Overman *et al.* (1951). The values for neonates are similar to those of Overman *et al.* (1951), but significantly ($P<0.001$) lower than those reported by Gottfried, Bogin, and Levycky (1954). Sodium levels in children aged one month to eleven years are also similar to those obtained from blood donors but significantly ($P<0.001$) higher than those from other groups reported by McFarlane *et al.* (1970), and significantly ($P<0.001$) lower than the levels reported by Joseph and Bergstrom (1961).

TABLE II

Age, Sex, Mean Values and Standard Deviations of Serum Electrolytes and Urea in Present Study

Age Range	*Sex*	*No. of Subjects*	*Electrolytes (mEq/L)*								*Urea mg/100ml*	
			Na^+		K^+		Cl^-		HCO_3^-			
			Mean	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
Cord blood*	M	21	141.0	6.3	6.2	0.7	104.5	4.3	22.9	4.3	19.7	6.9
	F	19	138.7	7.0	6.9	1.5	104.5	3.7	22.9	3.5	20.8	5.9
Neonates	M	18	137.1	5.5	5.8	1.1	104.5	3.4	22.2	3.5	23.1	6.3
	F	14	135.9	6.2	6.0	1.4	103.1	3.1	22.0	4.4	23.9	9.7
1mon-1yr	M	36	137.6	3.7	4.8	0.6	103.5	2.9	23.0	2.8	21.3	6.8
	F	23	137.9	4.3	4.8	0.6	101.8	3.8	24.8	4.5	22.4	8.1
Year 1–3	M	47	135.7	3.6	4.6	0.5	103.1	4.0	23.9	2.9	23.1	7.7
	F	27	137.1	4.6	4.8	0.7	104.5	3.6	23.7	3.3	21.7	5.9
,, 3–7	M	19	139.6	4.4	4.6	0.4	103.6	4.2	24.5	2.4	24.7	4.7
	F	15	137.5	3.1	4.6	0.9	104.7	3.3	24.7	3.4	19.7	5.7
,, 7–11	M	20	137.9	3.4	4.1	0.4	100.2	2.7	27.7	4.2	25.8	8.4
	F	14	137.3	4.8	4.3	0.4	103.5	2.6	26.6	2.2	23.1	6.0

* Included for comparison

TABLE III

Electrolytes and Urea Values in Different Age Groups

Age Range	*No. of Subjects*		*Electrolytes (mEq./L)* Na^+	K^+	Cl^-	HCO_3^-	*Urea mg./100ml.*
* Cord blood	40	Average	140	6.6	105	23	20
		S.D.	7.1	1.2	4.0	4.2	7.3
		Range	120–150	4.8–10.2	91–111	16–30	13–39
Neonates	32	Average	137	5.9	104	22	24
		S.D.	6.0	1.2	3.1	4.2	8.0
		Range	123–145	3.8–8.6	96–114	18–34	12–46
1 mon—11 years	201	Average	137	4.7	104	25	22
		S.D.	4.1	0.6	4.2	3.4	7.1
		Range	130–148	3.6–5.6	93–113	18–32	9–43

*Included for comparison

TABLE IV

Serum Electrolytes from Cord-Blood and Neonates in Present Study Compared with other Studies

Study	*No. of Subjects*		*Electrolytes (mEq./L)* Na^+	K^+	Cl^-	HCO_3^-	*Urea mg./100ml*
Present	40	Average	140	6.6	105	23	20
Cord-blood		S.D.	7.1	1.2	4.0	4.2	7.3
		Range	120–150	4.8–10.2	91–111	16–30	13–39
Overman *et al.* (1951)	19	Average S.D.	134 4.2	5.0 1.01	109 6.3	–	– –
Cord-blood		Range	126–141	3.8–7.2	99–117	–	–
Present	32	Average	137	5.9	104	22	24
Neonates		S.D.	6.0	1.2	3.1	4.2	8.0
		Range	123–145	3.8–8.6	96–114	18–34	12–46
Gottfried *et al.* (1954)	35	Average S.D.	143 5	–	111 3	20.5 1.4	
Babies 1–5 *days old*		Range	132–153	–	102–117	17–25	–
Overman *et. al.* (1951)	20	Average S.D.	139 4.7	4.3 0.3	105 5.8	– –	
48-hours olds		Range	130–146	3.9–4.7	95–118	–	

TABLE V

Serum Electrolytes and Urea in Present Study Compared with other Studies

Study	*No. of Subjects*		*Electrolytes (mEq./L)*				*Urea*
			Na^+	K^+	Cl^-	HCO_3^-	*mg/100ml*
Present study	201	Average	137	4.7	104	25	22
(1 mon–11 years)		S.D.	4.1	0.6	4.2	3.4	7.1
		Range	130–148	3.6–5.6	93–113	18—32	9–43
Joseph and Bergatrom (1961) (1 mon–16 years)	59	Average	146	–	–	–	–
		S.D.	5.6	–	–	–	–
		Range	–	–	–	–	–
Overman *et al.* (1951) (19–26 mons.)	11	Average	141	4.2	104	–	–
		S.D.	2.1	0.39	2.1	–	–
		Range	138–145	3.5–4.7	101–108	–	–
McFarlane *et al.* (1970) (All age groups)	948	Average	130	3.5	92	21	20
		S.D.	5.2	0.8	7.8	3.7	5.1
		Range	119–140	3.0–4.8	77–107	14–28	10–30
McFarlane *et al.* (1970) (Blood donors)	250	Average	137	3.7	95	26	19
		S.D.	3.7	0.4	4.1	2.6	6.9
		Range	130–144	3–4.4	85–105	20–30	5–43
*B. C. H. (Vade-mecum)		Range	136–145	4.–5.5	100–110	20–27	20–40
Edozien (1958) (All age groups)	352	Range	136–150	4.5–5.5	95–110	20–30	5–35

* Birmingham Children Hospital

Serum potassium

Serum potassium levels in cord-blood specimens were significantly ($P<0.025$) higher than those in neonates and significantly ($P<0.001$) higher than values in children aged 1 month to 11 years. The neonatal values were also significantly ($P<0.001$) higher than those for older children. Our potassium values for cord-blood specimens and for all age groups were significantly ($P<0.001$) higher than those reported by Overman *et al.* (1951) and McFarlane *et al.* (1970) for both blood donors and hospital population.

Serum chloride

The choloride levels for the cord-blood, neonates and for those aged one month to 11 years were similar to the values reported by Overman *et. al.* (1951). The levels were however, significantly ($P<0.001$, and $P<0.025$ respectively) lower than neonatal levels reported by Gottfried, Bogin, and Levycky (1954), and cord-blood values reported by Overman *et al.* (1951). The chloride values in the present study were also significantly ($P<0.001$) higher than those reported by McFarlane *et al.* (1970).

Serum bicarbonate

Bicarbonate values were lowest in the cord-blood specimens, but there was no significant difference between these values and those for neonates. Both cord-blood and neonatal blood values were significantly ($P<0.005$ and $P<0.001$ respectively) lower than those in children aged one month to eleven years. The neonatal bicarbonate values were similar to those reported by Gottfried, Bogin and Levycky (1954). The values for children were similar to those for blood donors but significantly ($P<0.001$) higher than those for the U.C.H. population reported by McFarlane *et al.* (1970).

Blood urea

Blood urea levels in neonates were the highest in the present study. The levels were significantly ($P<0.05$) higher than cord-blood urea, and not significantly different from the values in children. Urea levels in all groups were significantly ($P<0.001$) higher than those reported by McFarlane *et al.* (1970).

Discussion

In attempting to establish biochemical normals, it is important to ensure the accuracy of results. In the present study, this was achieved by selecting only healthy subjects, collecting specimens under specified standard conditions, and using an internationally recognized quality control—'Versatol Pediatric' and 'Versatol' for the control of the estimation of serum sodium, potassium, chloride and urea.

There are, to our knowledge, no published reports on electrolytes in healthy children in the tropics. Reports from temperate regions (Overman *et al.* 1951; Gottfried *et al.* 1954; Joseph and Bergstrom, 1961) are incomplete since none of the authors reported on all the serum components namely: sodium, potassium, chloride, bicarbonate and urea. Moreover, these studies were undertaken many years ago when techniques and equipments were probably not as refined as they are now. Reports in Nigerian adults (Edozien 1958), and in adults and children (McFarlane *et al.* 1970) are conflicting. Indeed, the report by McFarlane *et al.* (1970) concerned a large population of blood donors, student nurses, pregnant women, gynaecological cases and a random selection of specimens from 3,000 U.C.H. patients with unspecified diagnoses. Some of these patients were children. The values for the electrolytes in the present study for children aged 1 month to 11 years are similar to those obtained from blood donors, but significantly higher in all components than those in the other groups reported by McFarlane *et al.* (1970). This striking difference between the results of the two studies is most probably due to the differences in the subjects studied. Blood donors and student nurses were probably the only normal subjects in the study by McFarlane *et al.* (1970). Pregnancy is well known to be associated with hypervolaemia, and many of the hospital patients, particularly children, suffer from diarrhoea and some degree of dehydration. These observations are likely to explain the low levels obtained by McFarlane *et al.*

The range for serum sodium (130–148 mEq/1) in the present study compares favourably with the British range of 136-145 mEq/1 (Birmingham Children Hospital Vade-mecum, 1970). We have failed to confirm the findings of McFarlane *et al.* (1970) who reported higher mean serum sodium levels in males than in females.

The serum potassium levels in the cord-blood specimens and in neonates in the present study are significantly higher than those reported by Overman *et al.* (1951), and Gottfried *et al.* (1954). Some of the values in the present study are similar to those found in acute renal failure, and are probably a reflection of the well-known neonatal renal insufficiency. Higher potassium levels in neonates than in older children have also been reported in the American literature. The potassium range for children aged one month to eleven years in the present study is, however, similar to that reported for British children and also for Nigerian adults (Edozien 1958).

The chloride values in this study are significantly lower than those reported from North America, but the range is however, similar to that for British children. McFarlane *et al.* (1970) and Stone (1936) have reported low levels in Nigerians and Southern Rhodesian Africans respectively; Politzer, Barry and King, (1954) have also reported higher levels in South African Bantus; while Edozien (1958) reported values in Nigerians to be similar to Caucasians.

In the present study, serum bicarbonate levels in cord-blood and in neonates are similar to those reported by Gottfried *et al.* (1954), but in children aged one month to eleven years our findings are significantly lower. Kaiser, (1953), in an attempt to explain low levels of bicarbonates in neonates, has demonstrated acidosis in both arterial and venous blood just before birth. The bicarbonate range for subjects aged one month to eleven years is similar to the range for British children.

Significantly higher blood urea values in children in this study as compared to reports from adults by Edozien (1958) and McFarlane *et al.* (1970) is probably related to the good state of nutrition of our subjects.

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