Blood pressure in first 10 years of life: the Brompton study

Michael de Swiet, Peter Fayers, Elliott A Shinebourne

Abstract

***Objectives*—To determine the normal range of blood pressure and its pattern of change in the first 10 years of life. To estimate at what age (if any) children consistently appear in one part of the blood pressure distribution and at what age familial correlations in blood pressure become significant.**

***Design*—Longitudinal cohort study.**

***Setting*—South east England.**

***Subjects*—2088 children of both sexes born consecutively in Farnborough Hospital, Kent, and their parents.**

***Main outcome measure*—Blood pressure measured by Doppler ultrasonography and sphygmomanometry.**

***Results*—Systolic blood pressure rose from a mean of 88·5 mm Hg at age 6 months to 96·2 mm Hg at 8 years measured with a 8 cm cuff and from 89·1 mm Hg at age 5 years to 94·3 mm Hg at age 10 years measured with a 12 cm cuff. The larger cuff gave blood pressure readings about 6 mm Hg lower. This effect was independent of body weight and arm circumference. Diastolic blood pressure rose from 57·8 mm Hg at 5 years to 61·8 mm Hg at 10 years (12 cm cuff). There was only about 1 mm Hg difference between sexes. Blood pressure was correlated with weight, weight adjusted for height, height, and arm circumference at all ages studied. The correlation coefficient of repeated yearly measurements increased steadily with age from 0·28 at 2 years to 0·59 at 10 years. The correlation coefficients between child's blood pressure and mother's average blood pressure increased from 0·1 at age 1 year to 0·23 at age 10.**

***Conclusions*—Blood pressure changes relatively little between the ages of 6 months and 10 years. Yet because of the increasing strength of between occasion and family correlations, children are more consistently occupying a specific part of the blood pressure distribution as they grow older. Studies in children should help determine why some adults have hypertension and others do not.**

Introduction

Most studies of blood pressure in children have either examined small groups of children[1] or have been cross sectional.[2] The Brompton study is the first to follow one large group of children from birth until 10 years. This is important because changes in blood pressure at certain ages, such as those noted by the Task Force for Blood Pressure Control[3] at age 6 years, may represent differences in methods between studies of different groups of children rather than a genuine difference in blood pressure at this age. The Brompton study has also allowed examination of tracking phenomenon: At what age, if any, do children consistently appear in one part of the blood pressure distribution and what factors influence which part of the blood pressure distribution they occupy? We have presented reports concerning the blood pressure distribution up to age 6 years and tracking in the first 5 years of life.[4 5]

Subjects and methods

The parents of 2088 children born consecutively at Farnborough Hospital, Kent, between April 1975 and May 1977 were approached for permission to enter their children into the study. The only exceptions were parents who knew that they would be moving from the neighbourhood within six months. The parents of 88 children refused to participate, and 105 children were born before 37 weeks' gestation, leaving a total of 1895 in the study.

Nurses measured the blood pressures of the children using the non-invasive Parks Doppler ultrasound system[6] and random zero sphygmomanometry at the approximate ages of 4 days, 6 weeks, 6 months, 1 year, and yearly thereafter until May 1986. Thus all the children remaining in this study were at least 9 years old and some were 10. At each age three readings were taken immediately after each other and the mean of these three values was taken as the blood pressure. From the age of 4 years, blood pressure was measured by the Doppler system followed by conventional sphygmomanometry, taking the fifth Korotkoff sound as the diastolic pressure. Three sphygmomanometer cuff sizes were used: 4 cm, 8 cm, and 12 cm cuffs with inflation bags measuring 4×13 cm, 8×12 cm, and 12×36 cm respectively. The largest cuff that could be comfortably applied to the child's upper arm was always used. In young children we have found no significant differences between intra-arterial and Doppler blood pressure measurements using these cuffs.[6] However, as the children grew older, systematic differences emerged in blood pressures, depending on the cuff used, that were independent of the relation between blood pressure and weight or arm circumference. The differences in blood pressure were small, being about 5 mm Hg between the 8 cm and 12 cm cuffs. Nevertheless, we have presented the blood pressures according to the cuff used.

Blood pressure was always measured on the right arm. Infants were studied lying flat, but after the age of 1 year blood pressure was measured sitting, with children at first in their mothers' laps and later on a chair. From the age of 4 years the children were rested for five minutes before taking measurements. No measurements were made while the children were eating or sucking (especially important in the infants)[7] or ill. Children were arbitrarily classified as ill if they were taking prescribed medicine. Children were weighed on bathroom scales, and their heights were measured (after 4 years) with a tape measure whenever blood pressure was measured.

Most (69%) of the measurements in children aged 4 days were made at home; the remainder were made in hospital. Measurements in children aged 6 weeks to 3 years were all made at home. At 4 years, we started making measurements at the children's schools, and by the age of 8 most (95%) were made at school. Infants were classified as awake if their eyes were open at the beginning of blood pressure measurement.[7] After the age of 1 year all the children were awake when they were studied. Only 449 children were studied at age 10 years compared with over 900 at all other ages. This was because the funding for the project related to calendar time rather than children's age.

We also measured the mother's blood pressure by conventional sphygmomanometry whenever the child's blood pressure was measured in hospital or at home. Father's blood pressure was measured at least once for 68% of the children. Further details of the methods are given elsewhere.[5-7]

Department of Paediatrics, National Heart and Lung Institute, Brompton Hospital, London SW3 6LY
Michael de Swiet, MD, *consultant physician*
Peter Fayers, BSC, *statistician*
Elliott A Shinebourne, FRCP, *consultant paediatric cardiologist*

Correspondence to: Dr M de Swiet, Queen Charlotte's Hospital, London W6 0XG.

BMJ 1992;**304**:23-6

STATISTICS

We analysed the data using the statistical package for the social sciences (SPSS). Serial pairwise correlation coefficients of blood pressure throughout the study period were calculated. However, because blood pressure is correlated with weight[5] and weight showed significant serial correlations (fat children tended to remain fat) we also calculated serial correlation of blood pressure adjusted for a function of weight. In a previous paper we used Quetelet's index (weight/height^2) to study the relation of blood pressure to obesity rather than to weight alone. However, this index varies with age and is not appropriate for schoolchildren.[8] Therefore in this study we used the index of Cole,[8] which takes into account the effect of age: (weight/excess weight for age)×(excess height for age/height)^p, where p is a function of age with values between 2 and 3.[8]

Results

Table I shows the number of children lost to follow up and those remaining in the study. Most children were lost because they moved out of the area rather than because they, or their parents, did not wish to participate. After a rapid initial loss of 300 children in the first year, there was a steady loss of 2-6% a year; in addition we failed to contact about 200 children (20%) each year. There is no reason to believe that the children lost to the study had different blood pressures from those remaining. For example, the blood pressure at 4 days old in the asleep infants who remained in the study until aged 10 years was 75 mm Hg and in those who were lost from the study by 10 years was 76 mm Hg.

Blood pressure in the boys was about 1 mm Hg greater than in the girls at all ages ($p<0·0001$) even after allowing for the effect of weight. However, this difference was so small that the results have been combined for further analyses. Table II gives the systolic blood pressure by age and cuff size in children awake at measurement up to age 10. The mean difference between these measurements by Doppler ultrasonography and sphygmomanometry was small, with conventional sphygmomanometry giving slightly higher pressures (3·3 (SD 5·9) mm Hg, n=3939), and therefore the values given for systolic blood pressure from age 4 onwards are measured by conventional sphygmomanometry as this is more representative of normal clinical practice. Mean blood pressure was lower when the larger cuff was used ($p<0·001$) for each age group (table II). Systolic blood pressure was relatively stable between the ages of 6 months and 10 years, increasing by 8-10 mm Hg when measured with an 8 cm cuff.

Table III shows similar data for diastolic blood pressure from age 5 years. Again diastolic blood pressure was lower when measured with the larger cuff, by 4·6 mm Hg between the ages of 5 and 8. Diastolic blood pressure rose by 4 mm Hg between the ages of 5 and 10 years when measured with the 12 cm cuff.

Table IV shows that blood pressure was significantly correlated with weight, adjusted weight, and arm circumference between the ages of 4 days and 10 years. From age 5 years, when we first started measuring height, blood pressure was also significantly correlated with height but not so strongly as with weight.

To examine the tracking phenomenon we derived matrices of correlation coefficients between blood pressures for all ages at which the children were studied (table V). These correlation coefficients (tracking coefficients) were all adjusted for differences in cuff size and for small between observer and between place of measurement (home versus school) effects. The correlation coefficients generally, and gradually, became stronger as the children grew older (figure). Up to the age of 1 year, the correlation coefficients were very weak; all were less than 0·2 and at ages 4 days, 6 weeks, and 6 months blood pressures were in effect not correlated with blood pressures later in life. However, after the age of 1 year the correlations became stronger so that the one year tracking coefficients (n *v* n-1) from 9 to 10 years was 0·58. At nearly all ages the two year (n *v* n-2), three year (n *v* n-3), and

TABLE I—*Numbers of children studied and lost to follow up*

Age	No of children	No lost from follow up	Deaths	No remaining	No failed to contact or ill	No of measurements analysed
4 Days	1895	88	10	1797	55	1742
6 Weeks	1797	20		1777	145	1632
6 Months	1777	34	5	1738	178	867*
1 Year	1738	57		1681	253	1323*
2 Years	1681	109	2	1570	248	1322
3 Years	1570	85	1	1484	266	1218
4 Years	1484	80	1	1403	254	1149
5 Years	1403	64		1339	344	995
6 Years	1339	35		1304	229	1075
7 Years	1304	41	1	1262	194	1068
8 Years	1262	27		1235	138	1097
9 Years	1235	24		1211	248	963
10 Years	1211					449†

*At ages 6 months and 1 year, 693 and 105 measurements were excluded because they were made with a 5 cm cuff which gave artificially high values.[4]
†Incomplete follow up.

TABLE II—*Systolic blood pressure (mm Hg) in awake children by age and cuff size*

	4 cm Cuff			8 cm Cuff			12 cm Cuff		
Age	No of children	Mean (SD) blood pressure	95th Centile	No of children	Mean (SD) blood pressure	95th Centile	No of children	Mean (SD) blood pressure	95th Centile
4 Days*	171	76·2 (9·9)	95						
6 Weeks*	1129	95·7 (10·7)	113						
6 Months	129	104·8 (10·7)	124	738	88·5 (12·3)	109			
1 Year				1323	93·4 (11·1)	112			
2 Years				1322	95·5 (10·6)	115			
3 Years				1218	96·8 (9·7)	115			
4 Years				1149	97·4 (9·3)	113			
5 Years				777	96·2 (9·4)	114	218	89·1 (9·3)	107
6 Years				449	95·8 (9·1)	112	626	90·0 (8·2)	104
7 Years				187	97·3 (9·2)	114	881	90·0 (8·6)	104
8 Years				55	96·2 (8·6)	110	1042	91·9 (8·4)	105
9 Years							963	92·3 (8·7)	106
10 Years							449	94·3 (8·8)	111

*Some of the babies were asleep at time of measurement.

TABLE III—*Diastolic blood pressure (mm Hg) in awake children by age and cuff size**

	8 mm Cuff			12 mm Cuff		
Age (years)	No of children	Mean (SD) blood pressure	95th Centile	No of children	Mean (SD) blood pressure	95th Centile
5	777	62·3 (9·5)	78	218	57·8 (9·5)	73
6	442	63·6 (9·4)	70	621	59·6 (9·5)	74
7	179	66·2 (7·6)	81	839	60·6 (8·2)	75
8	55	65·2 (7·8)	78	1016	60·7 (7·6)	74
9				954	60·2 (7·6)	73
10				442	61·8 (7·2)	75

*The numbers of children studied are less than in tables I and II because the diastolic blood pressure (Korotkoff V) could not be determined for every child.

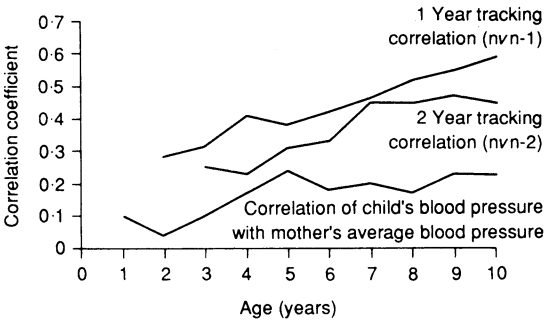
TABLE IV—*Correlation coefficients of systolic blood pressure with weight, adjusted weight, height, and arm circumference; all significant at* $p<0·0001$

Age	Weight	Adjusted weight*	Height	Arm circumference
4 Days	0·30			0·21
6 Weeks	0·16			0·18
6 Months	0·08			0·09
1 Year	0·13			0·26
2 Years	0·14			0·32
3 Years	0·19			0·31
4 Years	0·27			0·34
5 Years	0·28	0·28	0·19	0·26
6 Years	0·26	0·24	0·17	0·25
7 Years	0·27	0·27	0·22	0·19
8 Years	0·34	0·32	0·26	0·28
9 Years	0·38	0·35	0·29	0·35
10 Years	0·41	0·36	0·26	0·40

*Weight adjusted for height and age (see text).

more extended tracking coefficients were lower than the one year coefficient, but these also increased with age (figure). Adjustment of these correlations for a function of excess weight and excess height for age reduced the correlations a little but the trend was the same (table V).

We also investigated familial trends in blood pressure. At all ages up to 5 years, when the children went to school, the mothers' blood pressures were measured whenever the children were seen; the fathers' blood pressures were measured once for 68% of the children. The child's blood pressure was only weakly correlated with either simultaneously measured mother's blood pressure (aged 6 months and 4 years only) or the father's blood pressure (table VI). However, when all the mother's blood pressure measurements from the child's age of 4 days to 4 years were averaged this was correlated with the child's blood pressure with increasing strength from about 4 years onwards (table VI (figure)). Addition of the father's blood pressure measurement to give an average parents' blood pressure did not appreciably improve the correlation with the child's blood pressure (table VI).



Correlation coefficients for tracking and mothers' average blood pressure with increasing age

Discussion

The most striking feature of this study was the increase in strength of the tracking coefficient and of the correlation between mother's average and child's blood pressure over the age range 1 year to 10 years, an age range when the overall blood pressure was relatively stable. This suggests that as the children grow older the between occasion variability in blood pressure decreases and they gradually have blood pressures more consistently in one part of the blood pressure distribution. Results of other studies in which children have been followed into adult life[9] indicate that this part of the blood pressure distribution is likely to be that which they will occupy as adults.

Further work is necessary to identify the factors that influence the children's ultimate blood pressure. Our data confirm the well known familial factor,[10 11] which may be particularly marked when measurements are made at school.[12] We found a relation between children's and mother's blood pressure in particular; this is because we took more blood pressure measurements in mothers than fathers and thus had a more representative estimate of maternal blood pressure. Single measurements of maternal blood pressure, even when taken simultaneously with the child's blood pressure (age 4 days to 4 years) gave no stronger correlations than did the father's blood pressure.

TABLE VI—*Correlation coefficients of comparisons of parents' blood pressure and children's blood pressure at different ages (only correlation coefficients >0·1 are shown; all are significant at p<0·05)*

Age of child	Blood pressure: Mother	Mother's average	Father	Parents' average
6 Months	0·3	0·13	0·11	0·14
1 Year		0·10		
2 Years				
3 Years		0·10		0·11
4 Years	0·11	0·17		0·18
5 Years		0·24		0·24
6 Years		0·18		0·18
7 Years		0·20		0·20
8 Years		0·17	0·11	0·18
9 Years		0·23	0·12	0·25
10 Years		0·23		0·21

We also found that weight became a stronger predictor of blood pressure as the children grew older, with correlation coefficients of about 0·15 in the first years of life increasing to about 0·4 at age 9 to 10 years (table IV). The abnormally high correlation coefficient between weight and blood pressure at age 4 days (0·3) may be due to the relation between weight and the maturity of the fetus. Although we believe that all the infants we studied were born after 37 weeks' gestation, this may not have been so and preterm infants have lower blood pressures.[13]

When calculating correlations we adjusted for the effect of cuff size because blood pressures were lower when measured with larger cuffs (tables II and III). Using the largest cuff that can be placed on the child's arm is likely to give the most accurate estimate of blood pressure[14] as errors from too small a cuff are larger than errors from too big a cuff. Other workers have also found that cuff size influences apparent blood pressure, larger cuffs giving lower blood pressures.[2] Because heavier children tend to have larger arm circumferences we tended to use the larger cuffs in the heavier children. Although larger cuffs give lower blood pressures, blood pressure was positively though variably correlated with weight and arm circumference (table IV). The effect of using a large cuff therefore tends to oppose the relation of increasing weight to increasing blood pressure.

Because of the variable relation of blood pressure with weight at different ages we could not perform one multiple regression analysis to examine the separate effects of these variables. However, different multiple regression analyses of cuff size, weight, and arm circumference at all ages studied showed that the effect of weight was independent of cuff size; the effect of arm circumference, however, was dependent on

TABLE V—*Matrix of correlation coefficients for systolic blood pressure at different ages adjusted for cuff size (only correlation coefficients greater than 0·1 are shown; all are significant at p<0·0001). Figures in parentheses are correlation coefficients adjusted for weight*

Age	4 Days	6 Weeks	6 Months	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	9 Years	10 Years
4 Days			0·18 (0·17)	0·14 (0·13)									
6 Weeks						0·11	0·16 (0·15)	0·12 (0·11)	0·16 (0·15)	0·12 (0·12)	0·12 (0·12)		0·12 (0·11)
6 Months							(0·13)	0·16 (0·15)	0·13 (0·13)	0·14 (0·13)			
1 Year					0·28 (0·26)	0·25 (0·24)	0·25 (0·27)	0·21 (0·19)	0·17 (0·16)	0·18 (0·16)	0·16 (0·14)	0·22 (0·20)	0·20 (0·21)
2 Years						0·31 (0·29)	0·23 (0·21)	0·20 (0·29)	0·23 (0·25)	0·22 (0·26)	0·20 (0·24)	0·24 (0·27)	0·26 (0·23)
3 Years							0·41 (0·38)	0·31 (0·27)	0·32 (0·29)	0·28 (0·25)	0·30 (0·26)	0·28 (0·24)	0·30 (0·27)
4 Years								0·38 (0·34)	0·33 (0·30)	0·37 (0·33)	0·36 (0·33)	0·37 (0·35)	0·36 (0·34)
5 Years									0·42 (0·42)	0·45 (0·45)	0·43 (0·43)	0·41 (0·41)	0·46 (0·43)
6 Years										0·46 (0·46)	0·45 (0·44)	0·47 (0·47)	0·46 (0·45)
7 Years											0·52 (0·52)	0·47 (0·47)	0·47 (0·48)
8 Years												0·55 (0·55)	0·45 (0·45)
9 Years													0·59 (0·58)

cuff size with significant interaction between the two variables. In addition, part of the effect of arm circumference on blood pressure was explained by the correlation of arm circumference and weight.

Although the tracking correlation increased with age to 0·59 at 10 years, the strength of this correlation indicates that tracking accounts for only about 35% of blood pressure variability in children aged 10; 65% of the variability was between occasion variability. Thus children still have variable blood pressure even at the age of 10 years. We therefore believe that blood pressure is too variable to recommend screening of unselected children at 10 years.

It has recently been shown that geographical factors which affect adult blood pressure independently of social class are already operating in children aged 5-6.[2] In areas where adults tend to have high blood pressures children have blood pressures 5-6 mm Hg higher than children living in low blood pressure areas.[2] Other studies have shown the importance of dietary sodium, even in the first year of life, in relation to blood pressure.[15] It is likely that there are other antecedents of high blood pressure apart from those described and cited above, and the evidence of the Brompton study is that childhood would be a profitable time to look for these factors.

We thank the British Heart Foundation and the Medical Research Council for financial support.

1 Burke GL, Voors AW, Shear CL, Webber LS, Smoak CG, Cresanata JL, *et al.* Blood pressure. *Pediatrics* 1987;**80**(suppl):784-8.
2 Whincup PH, Cook DH, Shaper AG. Early influences on blood pressure: a study of children aged 5-7 years. *BMJ* 1989;**299**:587-91.
3 Task Force on Blood Pressure Control in Children. Report on the second task force on blood pressure control in children, 1987. *Pediatrics* 1987;**79**:1-25.
4 de Swiet M, Fayers P, Shinebourne EA. The value of repeated blood pressure measurements in children—the Brompton study. *BMJ* 1980;**280**: 1567-9.
5 de Swiet M, Fayers P, Shinebourne EA. Blood pressure in 4 and 5 year old children: the effects of environment and other factors in its measurement. The Brompton study. *J Hypertens* 1984;**2**:501-5.
6 de Swiet M, Fayers P, Shinebourne EA. Systolic blood pressure in a population of infants in the first year of life: the Brompton study. *Pediatrics* 1980; **65**:1028-35.
7 de Swiet M, Fancourt R, Peto J. Systolic blood pressure variation during the first 6 days of life. *Clin Sci* 1975;**49**:557-61.
8 Cole TJ. Weight/height^p compared to weight/height^2 for assessing adiposity in childhood: influence of age and bone age during puberty. *Ann Hum Biol* 1986;13:433-51.
9 Rosner B, Hennekens CH, Kass EH, Miall WE. Age-specific correlation analysis of longitudinal blood pressure data. *Am J Epidemiol* 1977;**106**: 306-13.
10 Clarke WR, Schrott HG, Burns TL, Sing CF, Laver RM. Aggregation of blood pressure in the families of children with labile high systolic blood pressure. The Muscatine study. *Am J Epidemiol* 1986;**123**:67-80.
11 Shear CL, Burke GL, Freedman DS, Berenson GS. Value of childhood blood pressure measurements and family history in predicting future blood pressure status: results from 8 years of follow-up in the Bogalusa heart study. *Pediatrics* 1986;**77**:862-9.
12 Wilson PD, Ferencz C, Dischinger PC, Brenner JI, Zeger SL. Twenty four hour ambulatory blood pressure in normotensive adolescent children of hypertensive and normotensive patients. *Am J Epidemiol* 1988;**127**:946-54.
13 Versmold HT, Kitterman JA, Phibbs RH, Gregory GA, Tooley WH. Aortic blood pressure during the first 12 hours of life in infants with birth weight 610 to 4220 grams. *Pediatrics* 1981;**67**: 607-13.
14 de Swiet M, Dillon MJ, Littler WAW, O'Brien E, Padfield PL, Petrie JC. Measurement of blood pressure in children. *BMJ* 1989;**299**:497.
15 Hofman A, Hazebroek A, Valken Burg HA. A randomised trial of sodium intake and blood pressure in new born infants. *JAMA* 1983;**250**:370-3.

(Accepted 18 October 1991)

Homozygous haemoglobin O disease and conjugated hyperbilirubinaemia in a Sudanese family

S A Ibrahim, Daoud Mustafa, A O Mohamed, M Beshir Mohed

Departments of Biochemistry and Medicine, Faculty of Medicine, PO Box 102, Khartoum, Sudan
S A Ibrahim, MRCP, *professor of biochemistry*
Daoud Mustafa, FRCP, *professor of medicine*
A O Mohamed, MB, *teaching assistant, biochemistry*
M Beshir Mohed, DIP MALARIA, *chief laboratory assistant, biochemistry*

Correspondence to: Professor Ibrahim.

BMJ 1992;**304**:26-7

Haemoglobin O Arab was first reported in two children of an Arab family who were suffering from sickle cell Hb O trait.[1] In the Sudan 11 instances of the carrier trait for Hb O were found in 9100 unselected blood samples in Khartoum.[2] Homozygosity for Hb O Arab has hitherto not been reported. We describe three cases of homozygous Hb O Arab with conjugated hyperbilirubinaemia in a Sudanese family.

Case reports

CASE 1

A Sudanese woman aged 27 was admitted to Khartoum Teaching Hospital in 1989 complaining of fever, jaundice, and a painful vulval swelling. Since the age of 8 years she had suffered from repeated attacks of jaundice, often precipitated by bouts of fever. In 1981 and 1987 she had been admitted to hospital and was diagnosed as having haemolytic anaemia. On admission in 1989, she had a temperature of 38·9°C and a spleen that was just palpable. She had a small abscess in the vulva, which was drained. Investigations showed a haemoglobin concentration of 117 g/l, a white cell count of $8 \cdot 6 \times 10^9$/l, an erythrocyte sedimentation rate of 24 mm in the first hour (Westergen), and a negative blood film for malaria. Paper electrophoresis of haemoglobin in barbitone buffer (0·05 M, pH 8·6) detected Hb O Arab alone, which was subsequently confirmed by Professor Sir David Weatherall of the Nuffield Department of Clinical Medicine, Oxford. The table shows the rest of the findings.

Her urine contained excess urobilinogen but no bilirubin. The coproporphyrin content of urine was normal but thin layer chromatography showed a preponderance of isomer I.[3] After treatment she was discharged taking 5 mg folate daily.

Laboratory findings in three patients with homozygous Hb O disease (cases 1-3) and their brother (case 4)

Case No	Age (years)	Height (cm)	Weight (kg)	Adult haemoglobins	Haemoglobin g/l	Haemoglobin F (%)	Reticulocytes (%)	Serum bilirubin (µmol/l) Total	Serum bilirubin (µmol/l) Conjugated
1	27	140	46	O	117	1·2	5·8	129·2	47·6
2	23	144	48	O	112	2·3	3·3	59·5	32·3
3	15	132	36	O	101	1·3	3·8	51·0	28·9
4	12	138	43	A and O	95	0·5	3	42·5	30·6

CASES 2 AND 3

The table shows the findings in two younger sisters of the patient in case 1 (cases 2 and 3). In both cases urine examination showed excess urobilinogen but no bilirubin. Coproporphyrin concentrations were within normal limits with a preponderance of isomer I.

Case 4 is of a younger brother of the patients in cases 1-3 who was found to have conjugated hyperbilirubinaemia with a preponderance of urinary coproporphyrin I.

Comment

The clinical picture of homozygous Hb O Arab has hitherto not been reported. The members of this family are northern Sudanese of Arab ancestry. Homozygous O disease seems to start early in childhood and is always preceded by a febrile illness. Although malarial infection was suspected at various times in these three cases, the parasite was never detected in a peripheral blood film. It seems possible that in homozygous Hb O erythrocytes infected with the malaria parasite undergo immediate haemolysis and are eliminated from the circulation. This is supported by the fact that haemoglobin concentration was low (75 g/l) in the patient in case 1 when she was admitted to hospital in 1987. Thus Hb O Arab seems