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By

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Biochemical Analysis of the Liver

Functions

OF TWO HUNDRED SOUTHERN
RHODESIAN CHILDREN AND
YOUNG ADULTS
(PART I)

BY

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INTRODUCTION

That liver disease in Africa is a major health problem is well known; less well known and understood is the inter-relation of the various possible etiological factors. Higginson, *et al.*,^{1,2} in a study done on liver biopsies of various age groups in the Republic of South Africa examined the relationship between the fatty changes seen in kwashiorkor of children and the diffuse portal fibrosis and severe cirrhosis seen in adulthood. He concluded, "The age gap between the fatty

liver of kwashiorkor and appearance of the more severe degrees of diffuse portal fibrosis indicated that the latter was not a direct sequel of kwashiorkor."¹ This conclusion would indicate that histologically normal liver parenchyma can be regained during adolescence and early adult life despite the most severe form of malnutrition in childhood. Thus the presence of early poor nutrition would not seem to be an important etiological factor in the development of the severe adult liver disease seen in Southern Africa.

Higginson does point out, however, that "it would appear that in childhood, abnormalities of liver metabolism may arise in the Bantu which are not necessarily reflected by histologic liver damage. There is some evidence that these abnormalities persist into adult life, and are irreversible."¹ The kind and extent of these metabolic abnormalities which persist from childhood into adult life have not been well studied or documented, and it was the purpose of this research to investigate biochemically the residual functional impairment of the liver allegedly caused by early malnutrition. A secondary purpose of this research was simply to make preliminary determinations of the "normal" biochemical values of liver function in the children and young adults of Southern Rhodesia.

Michael Gelfand has conveniently labelled the age group which was scrutinised in this study as "the silent period of liver disease."³ From the ages of five to 15, the Rhodesian African, according to Gelfand, is relatively free from signs and symptoms of liver pathology. This age group was extended to 20 years of age in this investigation with the hope of seeing some of the acute pathological insults to the liver (such as hepatitis, liver necrosis, cirrhosis, and carcinoma), which Gelfand indicated as beginning after 15 years of age.

Within this age group the present investigation examined such factors as sex, age, nutrition, and state of health in order to determine what effects they might have upon the liver function tests.

METHODS AND PROCEDURES

For three-and-a-half months in the summer of 1962, this research project was performed at Mpilo Central Hospital in Bulawayo, Southern Rhodesia. During that time medical and biochemical examinations were performed on 200 children and young adults who were seen as out-patients at the hospital.

These subjects were not randomly selected children, but partially selected ones. All were well enough to be ambulatory out-patients. The obvious and intended bias was that they were

children with various minor complaints, the majority having diseases unrelated to the liver but some with diseases which allegedly would affect liver function.

Within the selected age-group of five to 20 years, three subgroups were made according to age: five to 10, 10 to 15, and 15 to 20. By comparing the biochemical liver functions of these three age blocks, it was felt that detection of any regression or progression of liver dysfunction within the "silent period" could be made. The numerical distribution within these subgroups was as follows: 65 subjects of ages five to 10, 114 of ages 11 to 15, 21 of ages 16 to 20.

Further selection of the subjects was made according to sex. Of greater interest were, of course, the male children since the incidence of adult liver disease in males is significantly higher than in females. Thus only 65 females were examined, as compared to 135 males.

By means of a medical history, the present nutritional intake, as well as past and present illnesses of the subjects, was recorded. This was accomplished through an interpreter, and since the children were seldom accompanied by an adult, the histories must be considered inadequate. Even so, since this is one of the pertinent problems of twentieth century medical practice in Africa, it must be grappled with and statistically considered.

Since the staple food of the African diet in this area is maize, the determination of dietary adequacy was based upon the meat, milk, and other protein supplements to this staple. The subjects were placed into three categories according to their protein intake; the arbitrary term "poor" was applied to diets which contained meat, milk, and other proteins less than once a day; "fair" was applied to diets having meat but no other proteins at least once a day; "good" designated diets containing meat, milk, and other proteins at least once a day. In these selected subjects, 37 had "poor" diets, 53 had "fair," and 110 had "good."

Also elicited by history was information concerning those past and present illnesses which presumed to affect the liver. The most prominent and recurring symptom was haematuria, and for the present investigation, this symptom was presumed to represent bilharziasis probably due to *Schistosoma haematobium*. Although these blood flukes present in Southern Rhodesia are thought to affect mainly the bladder, involvement of the liver is also presumed. In this study patients with the symptom of haematuria were therefore categorised as having a positive history for liver-involving illnesses in order to determine

if the liver function tests were in fact significantly altered with this disease. Additional inquiries about other symptoms and consequent diseases, such as body swelling (kwashiorkor), jaundice (hepatitis), worms, malaria and any hospitalisations were rarely fruitful.

In addition to this historical data, a complete medical examination was performed, the most pertinent physical finding of this examination being hepatomegaly. From this historical and physical data, the subjects were divided into five groups; those with negative past and present liver-affecting illnesses and negative physical examinations (labelled "normal"), those with past history of haematuria (labelled "P.H."), those with present illness of haematuria (labelled "P.I."), those with past and present history of malaria, whether treated or not (labelled "malaria"), and those with palpable livers (labelled "hepatomegaly"). These categories were not exclusive of one another; in fact, much overlapping of subjects in the "abnormal" groups was present. This particular breakdown was made in order to determine which aspects of history and physical, if any, were associated with significant biochemical liver dysfunction. Eighty-eight of the 200 subjects were found who could be classified under "normal," 10 had "P.H." of haematuria, 35 had "P.I." of haematuria, 31 had had malaria and 55 had hepatomegaly.

Thus the biochemical data collected on these 200 African children and young adults was arranged in four major ways: according to age, sex, nutrition, and state of past and present health.

The tests performed on these 200 subjects were 11 fairly standard serum biochemical determinations for liver function: haemoglobin, total serum protein, serum protein electrophoresis, bromsulphathidine, total bilirubin, alkaline phosphatase, serum glutamic pyruvic transaminase, isocitric dehydrogenase, zinc sulphate and thymol turbidity. Most of the biochemical procedures employed in this study were the ones used at Mpilo Central Hospital so that the results could be directly applied to the local situation. When, however, more extensive tests were desired (such as paper electrophoresis, the enzyme tests, and the bromsulphalein test), these were imported from the U.S.A.

The photoelectric determinations were performed on a Coleman Junior Spectrophotometer (19 mm. tube).

RESULTS

The mean values for the biochemical liver function tests of the 200 subjects can be seen in

Table I, as compared with the generally accepted normal ranges for these biochemical tests. Not all of the 11 biochemical tests were performed on all 200 subjects because of the limitation of certain chemical supplies and technical difficulties.

The overall average for haemoglobin is, of course, not too revealing since the difference between the sexes is well recognised. The values of 15.9gm./100 ml. does, however, fall well within the normally accepted range.

Likewise, the total serum protein value of 7.6 gm./100 ml. is within the normal range. The fractionisation of the serum proteins by paper electrophoresis is considerably different from what is "normally" found with the Spinco B Procedure. It must be remembered in analysing this data that the "range of normal" varies considerably with the method used and also with the individual laboratory techniques. Ehrmantraut has excellently pointed this out.¹⁷

With this important limitation in mind, the mean values of Rhodesian subjects can still be profitably compared with those of so-called "normal" American subjects in order to discover if any outstanding differences are present. Using the "range of normal" as the physiological standard deviation from the average value of normal individuals, as obtained by Procedure B of the Spinco Model R System,¹⁷ one can see the most striking differences between this range and the Rhodesian mean values in the albumin and gamma globulin fractions. The albumin in the African falls below the "normal" range; the gamma globulin is above. With the broader range of normal values as found in the 11 studies on bromphenol-blue dye paper electrophoresis,¹⁷ however, the Rhodesian values do fall within the "normal" range. (The bromphenol-blue dye was used in the paper electrophoresis method in this research, but the Spinco Procedure B was the *exact* method and instrumentation used). There-

Table I

MEAN VALUES OF BIOCHEMICAL LIVER FUNCTION TESTS ON SOUTHERN RHODESIAN CHILDREN AND YOUNG ADULTS, AS COMPARED WITH ACCEPTED RANGE OF NORMAL VALUES FOR THESE TESTS

	Rhodesian Mean Values	(n)*	Ranges of Normal	
Haemoglobin in gm./100 ml.	15.9	(194)		12-17—adult males 11-15—adult females
Total serum protein in gm./100 ml.	7.6	(200)		6.8-8.05
Serum electrophoresis in per cent.		(200)	Spinco Proced.B ¹⁷	Bromphenol-blue dye electrophor. ¹⁷
Albumin	55.0		58.27-69.17	44-71
a ₁	4.3		1.50- 4.98	
a ₂	9.7		7.15-12.95	5.1-12.0
b	10.9		8.59-12.35	
g	20.0		9.76-14.28	11.3-23.6
BSP in % dye retained	2.4	(178)		0-518
Total bilirubin in mg./100 ml.	0.38	(188)		0.2-0.88
Alkaline phosphatase in Bodansky U./100 ml.	10.5	(190)	Children 5.0-12.0	Adults ¹⁹ 1.5-4.0
SGOT in Sigma-Frankel U./ml.	38	(199)		8-5011
SGPT in Sigma-Frankel U./ml.	24	(196)		5-4511
ICD in Sigma U./ml.	189	(144)		50-27514
ZnSO ₄ in Kankel units	2.6	(128)		2-8715
Thymol turbidity in Maclagan units	12.2	(199)		0-416, 20

(n)* = Number of subjects on which the respective tests were performed.

fore, the importance of establishing narrower, more locally specific and reproducible ranges of normal can be appreciated.

In the bromsulphalein, total bilirubin, serum glutamic-oxalacetic transaminase, serum glutamic pyruvic transaminase, isocitric dehydrogenase, and zinc sulphate determinations, the mean values of the Rhodesian subjects fell within the normal ranges accepted in the West. The alkaline phosphatase determination by Klein, Read, and Babson (called Phosphatabs-Alkaline Quantitative, Warner-Chilcott) was felt by this examiner to be

not completely satisfactory in consistent colour development; the overall mean value of 10.5 Bodansky units/100 m. was well above the accepted adult range but within the range felt to be "normal" in children. The fact that approximately half of the Rhodesian subjects were over 12 years of age and half under 12 makes this overall comparison difficult.

Concerning the thymol turbidity test, the average Rhodesian value of 12.2 units "by MacLagan's method" is considerably above the nought to four units of the "normal" range originally described

Table II

AVERAGE VALUES OF BIOCHEMICAL LIVER FUNCTION TESTS ACCORDING TO SEX AND AGE OF SOUTHERN RHODESIAN SUBJECTS

Ages of males	5-10	(n)*	11-15	(n)*	15-20	(n)*
Hgb (gm./100 ml.)	15.1	(36)	16.2	(76)	17.9	(20)
TSP (gm./100 ml.)	7.51	(37)	7.67	(77)	7.75	(21)
Electrophoresis (per cent.)—						
Albumin	54.3	(37)	54.8	(77)	53.9	(21)
a ₁	4.5	(37)	4.3	(77)	4.4	(21)
a ₂	10.0	(37)	9.6	(77)	9.5	(21)
b	11.3	(37)	11.1	(77)	11.7	(21)
g	20.0	(37)	20.1	(77)	20.5	(21)
BSP (% retained)	1.1	(34)	2.6	(73)	4.7	(19)
Bili (mg./100 ml.)	0.3	(34)	0.4	(75)	0.4	(21)
Alk. phos. (Bod./100 ml.)	10.3	(35)	11.5	(76)	6.5	(21)
SGOT (S-F U./ml.)	36	(37)	44	(77)	46	(20)
SGPT (S-F U./ml.)	21	(37)	27	(77)	35	(19)
ICD (Sig. U./ml.)	170	(25)	190	(54)	202	(7)
ZnSO ₄ (Kankel U.)	2.4	(25)	2.5	(41)	2.6	(5)
Thy. turb. (M.U.)	13.5	(37)	11.4	(77)	10.5	(21)
Ages of females	5-10	(n)*	11-15	(n)*		
Hgb (gm./100 ml.)	15.0	(28)	15.7	(34)		
TSP (gm./100 ml.)	7.49	(28)	7.72	(37)		
Electrophoresis (per cent.)—						
Albumin	56.7	(28)	55.3	(37)		
a ₁	4.2	(28)	4.3	(37)		
a ₂	9.7	(28)	9.8	(37)		
b	9.9	(28)	10.4	(37)		
g	19.4	(28)	20.2	(37)		
BSP (% retained)	1.2	(18)	2.6	(34)		
Bili (mg./100 ml.)	0.4	(24)	0.4	(34)		
Alk. phos. (Bod./100 ml.)	11.6	(25)	10.1	(33)		
SGOT (S-F U./ml.)	34	(28)	30	(37)		
SGPT (S-F U./ml.)	19	(28)	16	(35)		
ICD (Sig. U./ml.)	191	(24)	173	(34)		
ZnSO ₄ (Kankel U.)	1.7	(25)	3.5	(32)		
Thy. turb. (M.U.)	11.2	(28)	14.7	(36)		

(n)* = Number of subjects on which the respective tests were performed.

by Maclagan.¹⁶ At Mpilo Central Hospital, the range of values considered "normal" extended to 20 units, and for this one particular test, all the equipment, chemicals, and calculations employed at that hospital were also used in this study. The resulting mean value of 12.2 units could, therefore, represent a variation in procedure or chemicals rather than a biochemical abnormality. The values for the thymol turbidity test found in this study, then, should be used only to evaluate the various groupings within this Rhodesian population and not be used extensively in comparison with outside normal values.

In examining the 200 subjects according to their sex and age groups, one can see in Table II the mean values of each of the liver function tests.

Milam and Muench established normal range of haemoglobin values for Negroes in North Carolina, U.S.A., and these compare interestingly with the values obtained in Southern Rhodesia. Their values in mg./100 ml. were as follows: for males under 12 years of age—9.72-14.05; for males over 12 years—11.26-16.25; for females under 12—10.44-13.82; for females over 12 years of age—9.30-15.02.²¹ As can be seen in Table II, the

Table III

STATISTICAL SIGNIFICANCE, AS EXPRESSED IN T-VALUE, OF THE DIFFERENCES IN THE BIOCHEMICAL VALUES BETWEEN THE SEX AND AGE GROUPS OF THE SOUTHERN RHODESIAN SUBJECTS

	Male 5-10 Compared with Male 11-15 T-Value	Male 11-15 Compared with Male 15-20 T-Value	Female 5-10 Compared with Female 11-15 T-Value
Hgb	4.4	4.8	2.35
TSP	1.6	0.6	0.19
Electrophoresis—			
Albumin	1.05	0.8	1.23
a ₁	—	—	0.46
a ₂	—	—	0.21
b	—	1.5	1.37
g	—	0.5	1.05
BSP	4.8	3.2	0.65
Bili	—	—	—
Alk. phos.	1.70	5.9	0.3
SGOT	1.00	0.2	0.21
SGPT	—	—	0.28
ICD	1.4	1.1	0.02
ZnSO ₄	—	—	0.35
Thy. turb.	1.4	0.5	0.18
	Male 5-10 Compared with Female 5-10 T-Value	Male 11-15 Compared with Female 11-15 T-Value	
Hgb	—	1.87	
TSP	0.2	0.5	
Electrophoresis—			
Albumin	2.1	0.53	
a ₁	1.5	—	
a ₂	—	—	
b	0.9	2.2	
g	0.9	—	
BSP	—	—	
Bili	—	—	
Alk. phos.	1.3	1.8	
SGOT	—	0.9	
SGPT	—	—	
ICD	0.1	1.32	
ZnSO ₄	1.7	—	
Thy. turb.	1.2	2.80	

Rhodesian averages for haemoglobin fall within these normal ranges, except the males of the 15 to 20 age group and the females of the five to 10 age group; in both of these cases, the Rhodesian average was significantly higher.

As seen in Table III the value of 16.2 mg./100 ml. for the 11 to 15 male age group is significantly higher than the 15.1 mg./100 ml. value for the five to 10 male age group; the same is true for the higher haemoglobin average of the 15 to 20 male age group as compared with that of the 11 to 15 male age group. These differences coincide well with the generally held concept that in males the "normal" haemoglobin values increase after puberty. Also the higher mean value of 15.7 mg./100 ml. for the 11 to 15 female age group as compared with the 15.0 mg./100 ml. value of the five to 10 female age group is statistically significant and especially interesting when one considers that after puberty the average haemoglobin value is generally conceded to be lower in females (as confirmed by Milam and Muench).²¹

In comparing the two sexes of the same age groups, no statistically significant differences are noted.

The average values for total serum protein likewise were within the normal ranges cited in Table I, and in comparing the age and sex groups among themselves, no significant T-value was obtained.

The electrophoresis of the serum proteins revealed that in all the sex and age groups the mean albumin values were below and the mean gamma globulin values above the "normal ranges" for

Spinco Procedure B method; yet comparison with each other revealed only two instances of statistically significant differences. One was in the comparison of the male five to 10 age group with the female five to 10 age group. The latter mean value of 56.7 per cent. was significantly higher than the former's 54.3 per cent. But the differences between the other protein fractions in these two groups were not statistically significant. The only other statistically significant difference in the protein fractions of the groups was the beta component in the comparison of the male 11 to 15 group with the female 11 to 15 group—in which the male value of 11.1 per cent. was significantly higher than the 10.4 per cent. of the females.

In the B.S.P. determination, the mean values of all the sex and age groups were within the normal limits even though the differences between the groups had some statistical significance.

The average values in all the groups for the bilirubin, SGOT, SGPT, ICD and ZnSO₄ tests were within normal limits, and no statistically significant differences were noted among the groups. The alkaline phosphatase average values in the five to 10 and 11 to 15 age groups for both sexes were within the limits of the normal values for children quoted earlier; the average value for the male 15 to 20 age group was predictively lower than the other age groups to a statistically significant degree, but its value of 6.5 Bodansky units/100 ml. was still above the "normal" range of 1.5-4.0 Bodansky units/100 ml.

With the thymol turbidity test, the mean values were within the "normal" limits set at Mpilo of 20 units, and the only statistically significant difference was between the female 11 to 15 age

Table IV

MEAN VALUES OF BIOCHEMICAL LIVER FUNCTION TESTS IN RELATION TO ESTIMATED NUTRITIONAL INTAKE OF SOUTHERN RHODESIAN SUBJECTS

Diets	"Good"	(n)*	"Fair"	(n)*	"Poor"	(n)*
Hgb (gm./100 ml.)	15.1	(106)	16.2	(52)	15.4	(37)
TSP (gm./100 ml.)	7.65	(110)	7.64	(53)	7.57	(37)
Electrophoresis (per cent.)						
Albumin	55.0	(110)	54.8	(53)	55.0	(37)
a ₁	4.3	(110)	4.4	(53)	4.4	(37)
a ₂	9.5	(110)	9.9	(53)	10.1	(37)
b	10.7	(110)	11.2	(53)	10.6	(37)
g	20.3	(110)	19.6	(53)	19.8	(37)

(n)* = Number of subjects on which the respective tests were performed.

Table V

STATISTICAL SIGNIFICANCE, AS EXPRESSED IN T-VALUES, OF THE DIFFERENCES IN THE BIOCHEMICAL VALUES BETWEEN THE CATEGORIES OF ESTIMATED NUTRITIONAL INTAKE OF SOUTHERN RHODESIAN SUBJECTS

	"Good" Compared with "Poor" T-Value	"Good" Compared with "Fair" T-Value	"Fair" Compared with "Poor" T-Value
Hgb	1.5	5.8	2.8
TSP	1.3	0.0	0.6
Electrophoresis—			
Albumin	0.0	0.0	0.2
a ₁	0.0	0.0	0.0
a ₂	2.5	1.6	0.5
b	0.0	2.3	1.7
g	1.0	1.6	0.0

group's high value of 14.7 units and the 11 to 15 age group's value of 11.4 units.

Dividing the 200 subjects into three groups according to the historical adequacy of their diets, one finds in examining the mean values of the three most pertinent biochemical tests some additional information about these Rhodesian children and young adults. As seen in Table IV, the average haemoglobin values for the three groups were within the "normal" range; however, the group classified as having a "Fair" diet had a statistically significant higher value than either of the other two groups, as evidenced by Table V.

The total serum protein values for each group were within the "normal" range with no significant T-value comparisons. In the electrophoresis, the alpha-2 value of 10.1 per cent. in the "Poor" dietary group was significantly higher than the alpha-2 value of 9.5 per cent. in the "good" dietary group although both fall within the normal limits. The beta fractionisation value of 11.2 per cent. in the "fair" group was also significantly higher than the beta-fraction average of 10.7 per cent in the "good" group. These were the only statistically significant differences found in the electrophoresis results of the three dietary groups.

Table VI

MEAN VALUES OF BIOCHEMICAL LIVER FUNCTION TESTS IN RELATION TO STATE OF PAST AND PRESENT HEALTH OF SOUTHERN RHODESIAN SUBJECTS

State of health	"Normal"	(n)*	P.H.	(n)*	P.I.	(n)*	Malaria	(n)*	Hepat.	(n)*
Hgb (gm./100 ml.)	15.7	(84)	17.2	(10)	16.1	(35)	15.9	(31)	15.9	(54)
TSP (gm./100 ml.)	7.56	(88)	7.77	(10)	7.69	(35)	7.77	(31)	7.73	(55)
Electrophoresis (%)—										
Albumin	55.7	(88)	54.6	(10)	53.4	(35)	53.4	(31)	54.6	(55)
a ₁	4.4	(88)	4.1	(10)	4.2	(35)	4.3	(31)	4.3	(55)
a ₂	9.8	(88)	9.2	(10)	9.9	(35)	9.6	(31)	9.8	(55)
b	10.5	(88)	10.7	(10)	11.7	(35)	11.3	(31)	11.3	(55)
g	19.6	(88)	21.3	(10)	20.8	(35)	21.4	(31)	20.0	(55)
Alk. phos. (Bod./100)	10.2	(81)	11.3	(10)	10.7	(34)	10.3	(31)	11.7	(53)
SGOT (S-F/ml.)	34	(88)	38	(10)	43	(35)	47	(32)	46	(55)

(n)* = Number of subjects on which the respective tests were performed.

Table VII

STATISTICAL SIGNIFICANCE, AS EXPRESSED IN T-VALUES, OF THE DIFFERENCES IN THE BIOCHEMICAL VALUES AMONG THE CATEGORIES OF PAST AND PRESENT STATE OF HEALTH OF SOUTHERN RHODESIAN SUBJECTS

	"Normal" Compared with P.H. T-Value	"Normal" Compared with P.I. T-Value	"Normal" Compared with Malaria T-Value
Hgb	3.18	1.4	—
TSP	0.2	1.2	0.0
Electrophoresis—			
Albumin	0.8	1.2	2.5
a ₁	0.0	0.0	0.6
a ₂	1.0	0.0	0.5
b	—	3.55	—
g	1.7	2.0	2.8
Alk. phos.	0.7	0.7	—
	"Normal" Compared with Hepatomegaly T-Value	P.H. Compared with P.I. T-Value	P.H. Compared with Malaria T-Value
Hgb	—	—	—
TSP	1.7	0.5	0.9
Electrophoresis—			
Albumin	1.4	0.7	0.5
a ₁	0.0	0.0	0.0
a ₂	0.0	0.9	0.7
b	2.8	1.82	1.1
g	0.8	1.3	—
Alk. phos.	2.0	0.3	0.8

Table VIII

SOUTHERN RHODESIAN SUBJECTS WITH ABNORMAL LIVER FUNCTION TESTS WHO GAVE POSITIVE HISTORIES AND/OR HAD HEPATOMEGALY

Liver Tests	Total Number	"Normal"	Hepato- megaly	Hepato Malaria	Hepato P.I.	Hepato P.H.
Serum protein above 6.8 gm./100 ml.	12	7	2	—	1	—
Serum albumin less than 50%	32	14	4	3	1	—
BSP above 5%	19	10	2	1	—	—
Total bilirubin above 0.8 mg./100 ml.	10	8	—	—	—	—
Alk. phos. above 16 Bod./100 ml.	25	8	4	2	1	1
SGOT above 50 S-FU/ml.	15	4	2	2	1	—
SGPT above 45 S-FU/ml.	7	1	—	2	1	—
I.C.D. above 275 SU./ml.	10	4	3	1	—	—
ZnSO ₄ above 8 Kunkel U	4	2	1	—	—	—
Thy. turb. above 20 M.U.	24	8	5	1	—	—

The last major division of these 200 children was according to general state of past and present health, particularly as it applied to the liver. As can be seen in Tables VI and VII, the small group of 10 subjects having a past history of haematuria had a significantly higher average haemoglobin value (17.2 mg./100 ml.) than that of the large (84) "normal" group (15.7 mg./100 ml.), but in examining these two groups one finds the "normal" group is fairly well distributed age-wise between the 5-20 age limits of the study whereas the average age for the small "P.H." group is 14.3 years. Therefore, more of the "adult" population is represented in the final average value for the "P.H." group, accounting for a significantly higher, more adult-like average haemoglobin value in this group.

All of the mean values in the separate groups for total serum protein were within "normal" limits (and no significant T-value differences were found). Concerning the electrophoretic fractionisation of the serum protein, the statistically significant differences were five in number. The albumin value of 55.7 per cent. for the "normal" group was significantly higher than the 53.4 per cent. value of the group having malaria in the past or at present. A significant T-value was also present in comparing the beta fraction of the "normal" group (10.5 per cent.) with the "P.I."

group (11.7 per cent.) and the "normal" group (10.5 per cent.) with the group having hepatomegaly (11.3 per cent.). Statistically significant differences were also found in the gamma globulin comparisons: a T-value of 2.0 was present comparing the "normal" group (19.6 per cent.) with the "P.I." group (21.3 per cent.) and the "normal" group (19.6 per cent.) with the "malaria" group (21.4 per cent.). It should be noted, however, that even the average values of the protein fractions for the "normal" group do not fall within the "normal" range established for the Spinco Procedure B; the albumin is still low and the gamma globulin high.

The results of the alkaline phosphatase test shows one statistically significant fact; the average value for the group having hepatomegaly is elevated as compared with the "normal" group value.

The SGOT average values all fall within the normal limits set by *Sigma*, which is significant in the fact that the presumptive diagnosis of acute *Schistosomiasis* and the presence of hepatomegaly were two of the groups here examined.

Before the summarising, it is interesting to observe from Table VIII how many of the subjects having abnormal liver function tests also gave positive histories or had positive physical findings.

(To be continued)

Hepato Mal. P.I.	P.I.	P.I. Malaria	P.H.	P.H. Malaria	Malaria	Bacterial Infection	Miscellaneous
—	—	—	1	—	1	—	—
1	2	—	—	1	2	2	"Worms" — 1 Goitre — 1
1	2	—	—	—	—	1	Goitre — 2
—	1	—	—	—	1	—	—
—	4	—	1	—	3	1	—
—	2	—	2	—	1	—	Goitre — 1
—	2	—	—	—	—	1	—
—	—	—	—	—	1	1	—
—	—	—	1	—	—	—	—
—	4	2	—	—	2	1	P.H. oedema — 1



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