THE SWEAT TEST IN CHILDREN WITH MALNUTRITION

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The increased concentration of chloride and sodium in the sweat in fibrocystic disease of the pancreas, or mucoviscidosis, is a phenomenon which is now well known. Several studies have confirmed the original work of Di Sant'Agnese in 1953 and the sweat test is now considered useful in the diagnosis of this condition. It is the only test which can establish the relationship among the various aspects of the disease and it can also be used to detect carriers of the genes responsible for the transmission of the defect. Such persons generally display no symptoms other than the sweat abnormality.

Since the clinical resemblance between kwashiorkor and certain hypoproteinic forms of cystic fibrosis of the pancreas is well known[1] it seemed to us interesting to undertake research to see whether the sweat anomaly exists to the same degree in kwashiorkor as it does in mucoviscidosis. At the same time we wished to investigate the incidence of cystic fibrosis of the pancreas in the African population, its presence in Africa having been demonstrated in 1952 when one of the authors (together with Camain) reported two certain cases of the disease.

These are the lines along which we conducted the investigation the first results of which are being reported in this paper**

Materials and Methods

Various methods of analyzing both the drops of sweat and the sweat collected from one part of the body have been suggested. We have used the method in which sweat is taken from the forehead following the technique developed in 1958 by Lestradet et al.[2] The advantage of this method lies in its relative simplicity and in the fact that it does not necessitate either a special room or medicinal injections.

With this method the children are simply placed in bed and sweating is encouraged by the use of two additional blankets. We

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Paper presented at the Second Middle Eastern - Mediterranean Pediatric Congress, Ankara, 1961.

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** Research done with the help of the National Center of Scientific Research.

limited the testing time to forty minutes but otherwise followed Lestradet. Quantitative analysis of the chloride was carried out according to the Schales and Schales method as modified by Lestradet.

One hundred and fifty children were tested in this fashion. Of these

69 were control cases (35 boys, 34 girls)

41 had kwashiorkor

32 were malnourished

8 had drepanocytosis.

Some among this group were tested repeatedly and 283 tests were carried out altogether. Tables 1 and 2 indicate the number of children tested, the sex and age distribution, and the number of tests carried out in each group.

TABLE 1

SWEAT TESTS - DAKAR 1961

	BOYS	GIRLS	TOTAL	NUMBER OF TESTS
Control Cases	35	34	69	150
Kwashiorkor	23	18	41	68
Malnutrition	10	22	32	49
Drepanocytosis	5	3	8	16
TOTAL	73	77	150	483

TABLE 2

AGE DISTRIBUTION OF TESTED CHILDREN

	BOYS			
	CONTROL CASES	KWASHIOR-KOR	MALNOUR-ISHED	DREPANOCY-TOSIS
Less than one year	14	0	2	0
1 year to 2 ½ years	15	23	7	1
Over 2 ½ years	6	0	1	4

GIRLS				
	CONTROL CASES	KWASHIOR-KOR	MALNOUR-ISHED	DREPANCY-TOSIS
Less than one year	13	0	7	0
1 year to 2 ½ years	12	18	9	2
Over 2 ½ years	9	0	6	1

We were asked to take a relatively large group of control cases in order to establish figures for the normal negro child and to study the influence of various factors, especially climate.

Among the sick children, we separated the group of children with kwashiorkor from the malnourished ones and created a special group for those with drepanocytosis.

Seven among the examined children were excluded from the study and were considered to be examples of the failure of the method. These were six girls who did not sweat at all during the time unit which we had fixed, and one boy who, on the contrary, perspired more than 1.50 Gm. in ten minutes. In this case the sweat had a concentration of 2 mEq./liter. This percentage of failure corresponds to that given by other authors regardless of the technique which was used.

This study led to the measurement of the *debit sudoral* (the total amount of sweat collected within the forty minute time unit of the test), and to the measurement of the concentration of chloride. In fact we now know that the concentration of sodium is precisely identical to that of chloride.

Results in Apparently Normal Negro Children (the Control Cases)

Sixty - nine children, 35 boys and 34 girls, underwent 150 tests in which the *debit sudoral* and the concentration of chloride were studied.

We found that the *debit sudoral* is not constant in any one child and great variations in the course of a 24 hour period, or from one day to the next, can exist in the same child. Therefore we join with Di Sant'Agnese, Gochberg and Julien Marie in feeling that the *debit sudoral* is not individually constant and that because of the

extreme variation we must be prudent in the interpretation of results. The general average drop size of the 69 control cases was 0.7557 Gm. The extremes were 0.1780 Gm. and 1.7993 Gm.

Sex distribution was not of any particular interest and, statistically, in our experience there appears to be little climatic influence since the individual variations are too great at different seasons of the year to be significant.

A comparison with the results obtained by other authors can be made only in cases where similar techniques have been used. Therefore we can only compare our figures with those obtained by Lestradet. In his 200 control cases he found the average drop size to be 0.6000 Gm. with extremes of 0.150 Gm. and 2 Gm. These results are not dissimilar from ours.

The concentration of chloride found in the sweat of the tested children is shown in the chart in fig. 1. The average is 32 mEq/liter $\pm$ Standard deviation $=$ 6.7.

Our research work has permitted us to see that age, sex and seasonal changes do not influence the concentration of chloride.

TABLE 3

CHLORIDE IN SWEAT (IN mEq./LITER)

Authors	Normal control cases	Mucoviscidosis	Hypotrophy	Kwashiorkor
Di Sant'Agnese and Darling, New York	32 (50) +	106 (50) +		
Hennequet and Julien Marie, Paris	31 (23) +	136 (8) +	47 (6) +	
Lestradet and Jacob, Paris	25 (200) +	120 (17) +		
Salazar de Sousa, Lisbon	35 (10) +		60 (20) +	
Senecal and Dan, Dakar	32 (69)		42 (32) +	16 (41) +

+ Number of tested children

We must point out, however, that we have not examined children in the first days of life and have not therefore been able to verify the fact that newborn babies display a greater elevation of chloride concentration than older children and adults as Lestradet claims.

Although the *debit sudoral* shows considerable changes in the same child from one test to another, the amount of chloride in the sweat remains perfectly stable under the same conditions. This agrees with the conclusions of Di Sant'Agnese, Gochberg and Julien Marie with regard to the complete independence of the concentration of chloride and the total amount of sweat.[3,4,5,6,7] The amounts were found to be comparable to those of Di Sant'Agnese, Hennequet and Julien Marie, even though their techniques of collecting sweat differed from ours.

By contrast our results are a little more elevated than those of Lestradet whose method we have nevertheless faithfully followed, particularly taking all precautions in order to prevent evaporation.

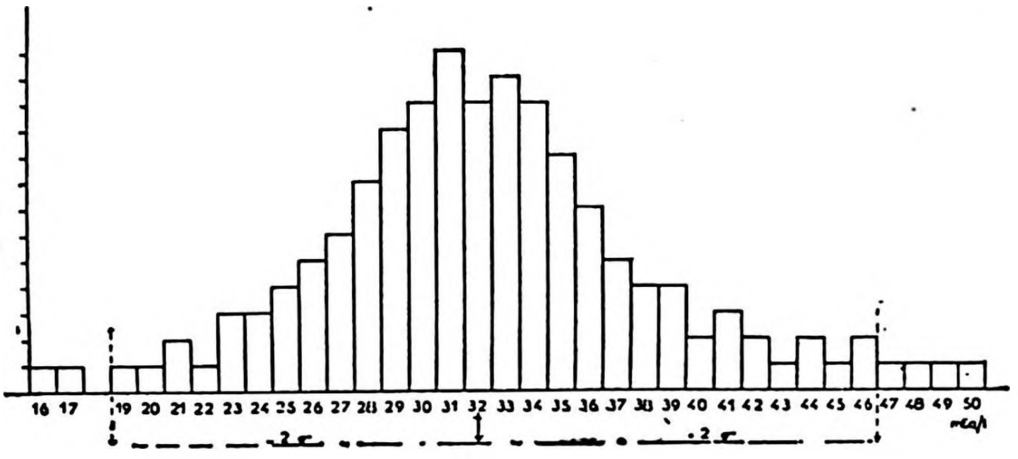

Figure 1. The concentration of chloride in the sweat of 69 control cases (150 tests).

Sweat Test in Children with Frank Kwashiorkor

Sixty - eight tests were done on 41 children of whom 23 were boys and 18 girls. They all had frank kwashiorkor in all its clinical stages, (swellings, depigmentation, angular cheilitis, modification of the hair, etc.), and biological signs, (average hypoproteinemia of 3.56 g. $\pm$ 0.68 p. 100).

We have seen no anomaly of the *debit sudoral,* but the amount of chloride was clearly lower than in the control cases. The average obtained is, in fact, 16 mEq./liter $\pm$ 1.5 and the histogram shows a perfectly grouped distribution.

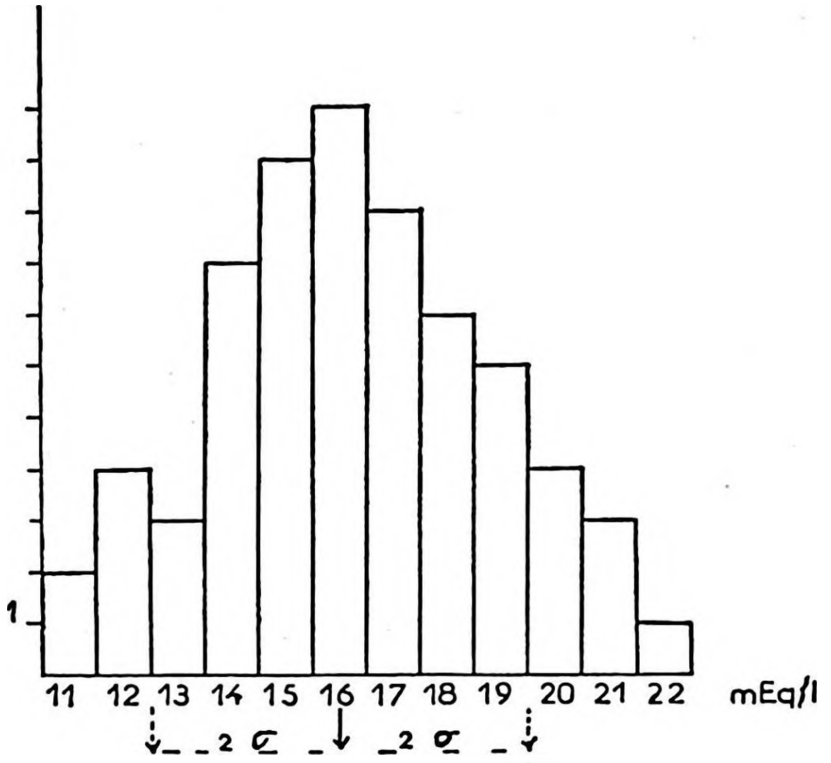

Figure 2. The concentration of chloride in the sweat of 68 cases of kwashiorkor - 68 tests.

There is no correlation between the amount of serum protein and that of sweat chloride.

Thus, although the clinical picture and the hypoproteinemia can be very similar in pancreatic cystic fibrosis and kwashiorkor, in kwashiorkor hypoproteinemia is present because of an absence, of protein, but in pancreatic cystic fibrosis hypoproteinemia exists because of a defect in the utilization of protein. In the first disease we have not found the hyperconcentration of the sweat which is the rule in the second. In this way we have a means of diagnosis which is easier than duodenal tubage and quicker than observing the progression of the disease.

The second interesting fact in our results is the verification of a hypoconcentration of sweat in kwashiorkor which points out, like the hyperconcentration of mucoviscidosis, the problem of understanding the physiologic mechanism of sweat secretion.

In order to try to clarify this mechanism, 18 patients were tested in the course of treatment, so as to study the evolution of this hypoconcentration. The slight differences and especially the small number of cases on which we based our study do not allow us, for the moment, to reach conclusions which would be statistically

accurate. Furthermore, we do not know the sweat concentration of chloride before the onset of kwashiorkor in these patients.

Sweat Test in Malnourished Children

Forty - nine tests were carried out on 32 children, of whom 10 were boys and 22 girls, with malnutrition.

By malnutrition or marasmus we mean the clinical picture seen in cases where the diet has a clearly insufficient caloric level but is otherwise well balanced in its greater constituents : protides, lipids and glucides. Malnutrition is therefore the opposite of kwashiorkor, which is an alimentary disequilibrium in which the caloric intake may be normal or even increased but with protein insufficiency.

The clinical and biological aspects of these two pictures are clearly different.[8] In undernourishment there is no edema, no cutaneo - mucous changes, no psychic disturbances; the serum protein is sub - normal and there is no fatty degeneration of the liver. All these points are contrary to those which are seen in kwashiorkor.

The difficulty is that it is very rare to come across pure forms of kwashiorkor and malnutrition. Most frequently the cases are those intermediary ones where the child is suffering from a diet which is both insufficient and unbalanced.

Apart from the individual variability, we have not seen any noteworthy difference in the *debit sudoral* of undernourished children.

As to the concentration of chloride in sweat, the widely distributed figures do not lend themselves to an easy statistical analysis, (fig. 3). The average is 42 mEq./liter $\pm$ 14.2 with the extremes of 17 mEq./liter and 78 mEq./liter. The average figure, more elevated than that of normal cases, is near to that found by Salazar de Sousa 60 mEq./liter (extremes : 15 and 95), in 20 hypothrepsic children, and by Hennequet and Julien Marie : 47 mEq./liter in 6 studied cases. It is probable that our elevated but relatively low figure and the distribution of our results are due to the frequency of the intermediary cases among our tested children.

The rate of proteinemia is, in fact, highly variable and among the normal figures we found some which were as low as those in kwashiorkor. Interestingly enough, in this group there is a definite correlation between the amount of proteinemia and the concentra-

tion of sweat, (fig. 3). The more elevated the proteinemia, the more concentrated the sweat. If we had only taken the cases with a proteinemia over six grams, the rates of the concentration of sweat would have reached those given by Salazar de Souza.

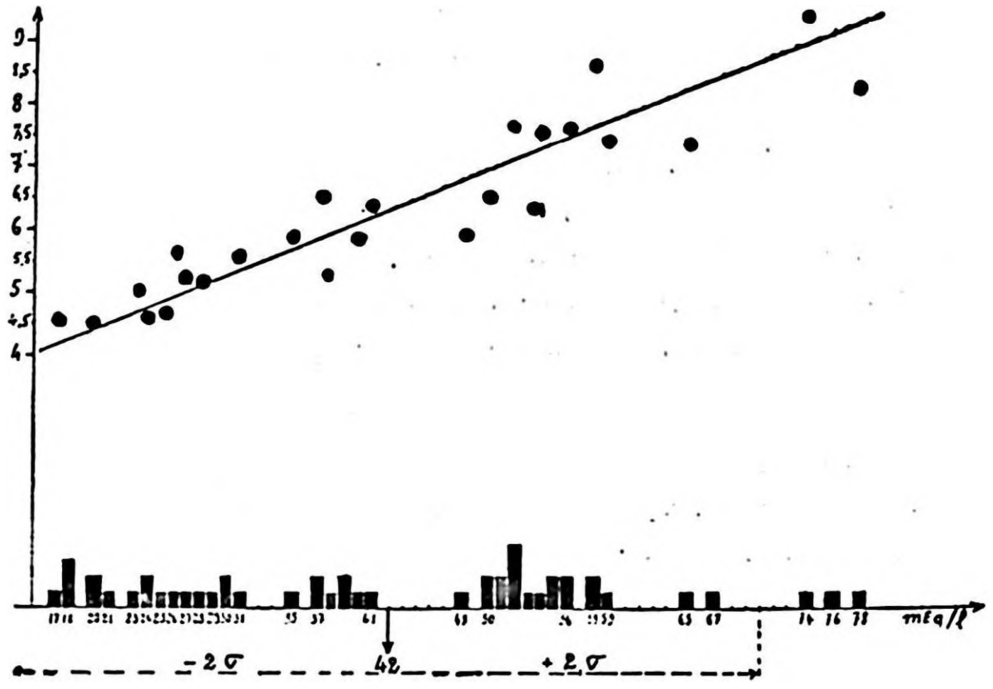

Figure 3. The concentration of chloride in the sweat of 32 cases of malnutrition-49 tests. The lower left scale indicates the number of tests, and the bars on this graph represent the total number of tests. Where the level of proteinemia was determined on these same 32 cases, it has been plotted as a circle on the upper graph. These two graphs are shown together to illustrate the fact that there is a correlation between the level of proteinemia and the hyperconcentration of the sweat. The higher the proteinemia, the greater the hyperconcentration of the sweat.

Thus we have confirmed, but not explained, the hyperconcentration of sweat in cases of undernourishment, which is opposite to the dilution observed in kwashiorkor. This opposition, a new element of differential diagnosis, can supply an argument in the ever discussed theory of the physiology of sweat secretion.

Sweat Test in Children with Drepanocytosis

The eight children with drepanocytosis showed a definite insufficiency in sweating during the fixed unit of the testing time. The same insufficiency was always encountered even though the test was repeated at least twice in these children. The extreme figures of the *debit sudoral* were 0.0821 Gm. and 0.0015 Gm., quantities which did not permit quantitative analysis. Although we have no explanation to give for this still unverified phenomenon, we have found it an interesting fact to note.

Conclusion

The first results obtained by the study of sweat in negro children are given. It appears that the *debit sudoral* and the concentration of chloride in the sweat fall within the same range in both white and negro children.

Hypoconcentration, which exists in kwashiorkor, is the opposite of the hyperconcentration which is present in cystic fibrosis of the pancreas, and gives in this way a good criterion of differential diagnosis but creates the same problems of physiopathology.

In malnutrition there seems to exist a certain hyperconcentration.

All these facts demonstrate that it is of great interest to continue the study in tropical countries.

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The authors wish to express their thanks to Professor G. Pille and his collaborators for the facilities which were made available in their laboratories at the Hôpital Dantec. Further thanks go to Drs. L. Masse and J. P. Moreigne who did the statistical calculations.

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