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ELECTROCARDIOGRAPHY AND CARBOHYDRATE METABOLISM

II. P-Wave Height (Lead I) in Presumably Healthy Young Men*

E. CHERASKIN, M.D., D.M.D., F.I.C.A., AND W. M. RINGSDORF, JR., D.M.D., M.S.

There is increasing awareness of relationships between cardiovascular disease and carbohydrate metabolism.[1-10] Within this area, there are several reports which note interesting correlations between electrocardiography and carbohydrate metabolism.[11-15] An earlier report in this series analyzed the duration of the P-wave in lead I with regard to postprandial blood glucose.[16] This paper, the second in the series, correlates another electrocardiographic parameter in presumably healthy young men with postprandial blood glucose. Specifically, an attempt will be made to answer the following three questions. (1) How reproducible is the measurement of P-wave height in lead I? (2) How constant is P-wave height (lead I) recorded 4 days apart in a group of presumably healthy young men consuming a regular diet? (3) Is there any relationship between the P-wave height (lead I) and blood glucose in healthy young men subsisting on a regular dietary regime for 4 days?

METHOD OF INVESTIGATION

Thirty-eight presumably healthy junior dental students participated in this study. On a Monday, routine electrocardiography (leads I to III) was performed at about 10:00 a.m. In addition, a 3-hr. postprandial blood glucose (Somogyi-Nelson method)[17, 18] was determined. On Friday of the same week at 10:00 a.m., electrocardiograms were again recorded and blood glucose assays were repeated.

The electrocardiographic patterns were read under a dissecting microscope with a magnification of 60×.[19] Each measurement was repeated (to ensure accuracy) by the same examiner, with no knowledge of the student's name, electrocardiographic lead or visit number.

RESULTS

Question 1. An attempt was first made to establish the constancy of the measuring technique. Table 1 lists the first and second P-wave height readings at the initial and final visits. Of the 76 duplicate measurements, 43 were different (table 2). Of these 43, 37 varied by 0.1 mm and 6 by 0.2 mm. The significant ($p < 0.01$) coefficient of correlation ($r = +0.927$) attests to the reproducibility of the measuring technique. Hence, a high degree of accuracy was achieved in measuring the P-wave height in lead I.

Question 2. How constant is the P-wave height (lead I) during a 4-day in-

* From the Department of Oral Medicine, University of Alabama Medical Center, Birmingham, Alabama.

TABLE 1
Frequency distribution of P-wave height

Case	First Visit			Second Visit		
	First reading	Second reading	Difference	First reading	Second reading	Difference
03286	0.6	0.6	0.0	0.9	0.8	0.1
03287	0.4	0.6	0.2	0.4	0.3	0.1
03290	0.1	0.1	0.0	0.4	0.6	0.2
03296	0.3	0.5	0.2	0.6	0.5	0.1
03298	0.8	0.8	0.0	0.9	0.9	0.0
03300	0.4	0.3	0.1	0.6	0.5	0.1
03301	0.5	0.4	0.1	0.3	0.3	0.0
03304	0.4	0.5	0.1	0.4	0.4	0.0
03305	0.9	0.8	0.1	0.8	0.8	0.0
03306	0.6	0.5	0.1	0.6	0.6	0.0
03307	0.6	0.8	0.2	0.7	0.8	0.1
03308	0.7	0.7	0.0	0.4	0.3	0.1
03309	0.6	0.5	0.1	0.4	0.5	0.1
03319	0.6	0.6	0.0	0.6	0.5	0.1
03321	0.6	0.7	0.1	0.6	0.6	0.0
03323	0.7	0.7	0.0	0.8	0.9	0.1
13158	0.8	0.8	0.0	0.5	0.4	0.1
13160	0.4	0.4	0.0	0.3	0.4	0.1
13163	0.7	0.7	0.0	0.6	0.6	0.0
13165	0.6	0.7	0.1	0.5	0.5	0.0
13167	0.5	0.5	0.0	0.4	0.3	0.1
13169	0.5	0.5	0.0	0.4	0.3	0.1
13170	0.3	0.3	0.0	0.4	0.5	0.1
13174	0.2	0.1	0.1	0.2	0.1	0.1
13176	0.7	0.6	0.1	0.6	0.7	0.1
13178	0.6	0.4	0.2	0.7	0.9	0.2
13179	0.5	0.6	0.1	0.3	0.2	0.1
13182	0.4	0.5	0.1	0.2	0.2	0.0
13184	0.9	1.0	0.1	1.0	1.0	0.0
13186	0.7	0.6	0.1	0.5	0.5	0.0
13191	0.1	0.1	0.0	0.9	0.9	0.0
13193	0.4	0.4	0.0	0.5	0.4	0.1
13194	1.0	0.9	0.1	0.6	0.6	0.0
13197	0.9	0.8	0.1	1.0	1.0	0.0
13198	0.1	0.1	0.0	0.2	0.3	0.1
13199	0.8	0.8	0.0	0.9	0.9	0.0
13203	0.4	0.5	0.1	0.3	0.3	0.0
13204	0.3	0.2	0.1	0.3	0.3	0.0

terval in healthy young men subsisting on a regular diet? Table 3 lists the mean initial and final P-wave heights. The coefficient of correlation proved to be -0.051, and its lack of significance is underscored by $p > 0.05$. Apparently, healthy young men subsisting on a regular diet did not show a constant electrocardiogram as expressed in P_1-wave height.

TABLE 2

Frequency distribution of P-wave height difference in lead I in duplicate measurements

Difference	No. of Subjects	Percentage of Subjects
mm		
0.0	33	43.4
0.1	37	48.7
0.2	6	7.9
Total	76	100.0

Question 3. It is abundantly clear that the P-wave height in lead I fluctuated from day to day. Although some of the changes may have been due to the method of measurement, undoubtedly other factors were also operative. The question now to be answered is whether there is any relationship between the P-wave height in lead I and carbohydrate metabolism. To answer this question, one must first examine the blood glucose levels recorded on Monday and Friday in these students.

Table 3 summarizes the nonfasting blood glucose determinations at these two visits. The initial and final values are 80.4 ± 9.3 and 81.9 ± 10.9 mg/100 ml, respectively. The lack of statistical significance is underscored by a coefficient of correlation of $+0.253$ and $p > 0.05$. Hence, it is obvious that blood glucose varied during the experimental period.

Figure 1 describes the differences in the initial and final values in P-wave height on the *abscissa* and those for blood glucose on the *ordinate*. The correlation coefficient of -0.385, $p < 0.05$, suggests that fluctuations in the electrocardiographic pattern paralleled changes in P_1-wave height. In other words, when blood glucose rose, P_1-wave height decreased. Conversely, when blood glucose declined, P_1-wave height rose. Thus, healthy young men subsisting on a regular diet demonstrated a significant negative relationship between P_1-wave height and blood glucose.

DISCUSSION

In an earlier report,[16] it was shown that there was a significant reproducibility of P_1-wave length as shown by a correlation coefficient of $+0.961$, significant at the 1 per cent confidence level. There is also a statistically significant reproducibility in measuring P_1-wave height as shown in this report by an $r = +0.927$ and a $p < 0.01$. However, with regard to P_1-wave length, 86.8 per cent of the duplicate measurements were identical, whereas here in connection with P_1-wave height, the frequency of identical readings was only 43.4 per cent. Hence, the conclusion may be drawn that P-wave height is not as reproducible as P-wave length.

It was shown earlier[16] that P_1-wave length varied considerably from day to day, as shown by a statistically insignificant ($p > 0.05$) correlation coefficient of $+0.260$. It has been reported in this study that there is also great

TABLE 3

Initial and final P-wave heights and blood glucose levels

Case	P-Wave Height			Blood Glucose		
	Initial	Final	Differences	Initial	Final	Differences
03321	0.65	0.60	−0.05	63	63	0
13191	0.55	0.90	+0.35	85	85	0
03300	0.35	0.55	+0.20	92	90	−2
03304	0.45	0.40	−0.05	80	78	−2
03307	0.70	0.75	+0.05	80	82	+2
13158	0.80	0.45	−0.35	85	83	−2
13174	0.15	0.40	+0.25	83	85	+2
13193	0.40	0.45	+0.05	92	90	−2
13204	0.25	0.30	+0.05	80	82	+2
03306	0.55	0.60	+0.05	83	80	−3
13163	0.70	0.60	−0.10	80	83	+3
13169	0.50	0.35	−0.15	87	84	−3
13170	0.30	0.45	+0.15	81	84	+3
13194	0.95	0.60	−0.35	80	83	+3
13176	0.65	0.65	0.00	70	74	+4
03286	0.60	0.85	+0.25	75	70	−5
13184	0.95	1.00	+0.10	83	78	−5
13198	0.10	0.25	+0.15	85	90	+5
13203	0.45	0.30	−0.15	87	82	−5
03298	0.80	0.90	+0.10	80	73	−7
13167	0.50	0.35	−0.15	83	90	+7
13178	0.50	0.80	+0.30	92	85	−7
13186	0.65	0.50	−0.15	85	92	+7
13197	0.85	1.00	+0.15	85	78	−7
13182	0.45	0.20	−0.25	75	83	+8
13199	0.80	0.90	+0.10	92	100	+8
03308	0.70	0.35	−0.35	75	84	+9
03319	0.60	0.55	−0.05	73	83	+10
13179	0.55	0.25	−0.30	95	105	+10
13165	0.65	0.50	−0.15	80	91	+11
13160	0.40	0.35	−0.05	70	83	+13
03290	0.10	0.50	+0.40	77	63	−14
03301	0.45	0.30	−0.15	57	71	+14
03323	0.70	0.85	+0.15	95	80	−15
03287	0.50	0.35	−0.15	65	80	+15
03296	0.40	0.55	+0.15	76	57	−19
03305	0.85	0.80	−0.05	91	60	−31
03309	0.55	0.45	−0.10	60	110	+50

fluctuation in the electrocardiographic P_1-wave height from day to day as demonstrated by an $r = -0.051$ and $p > 0.05$. Hence, the fluctuations in P-wave height seem to be greater than those in P-wave length. Part of the explanation may be the greater difficulty in measurement of height *versus* length.

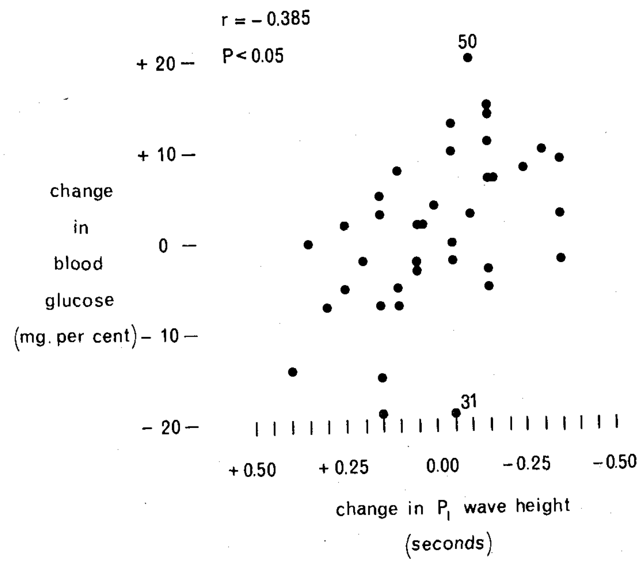

FIG. 1. The relationship of change in blood glucose and P_1-wave height during 3 days. The evidence suggests that, as blood glucose rises, P-wave height diminishes.

Finally, evidence has been offered[16] that the variation of P_1 length parallels the change in blood glucose only when the sign is disregarded. In contrast, the data with P_1-wave height suggest more orderly electrocardiographic and biochemical parallelisms. Thus, when P-wave height decreased, blood glucose rose. Conversely, when P-wave height increased, blood glucose increased.

Dubos,[20] in his writings about Claude Bernard and homeostasis, made the following relevant statement.

"He (Claude Bernard) emphasized that at all levels of biological organization, in plants as well as in animals, survival and fitness are conditioned by the ability of the organism to resist the impact of the outside world and maintain constant *within narrow limits* (*italics* added) the physicochemical characteristics of its internal environment."

On the assumption that the steady state is indeed steady, the evidence here suggests that the inconstancy of the P_1-wave height and blood glucose significantly correlate.

SUMMARY

1. Thirty-eight presumably healthy junior dental students participated in this experiment, in which the height of the P-wave in lead I and blood glucose by the Somogyi-Nelson method were determined at 10:00 a.m. on Monday and Friday of the same week.

2. The evidence suggests that the measurement of P_1-wave height is highly

reproducible. Also, the data suggest that, for the group, P-wave height and blood glucose are quite inconstant from Monday to Friday.

3. It is fair to assume from the information available in this report that a significant negative relationship exists between P-wave height in lead I and blood glucose.

E. Cheraskin, M.D., D.M.D., F.I.C.A.
Dept. of Oral Medicine
Univ. of Alabama Medical Center
Birmingham, Alabama 35233

REFERENCES

1. Shipp, J.: Diabetes cure would lessen heart disease. (Address before the Medical Progress Assembly sponsored by the Birmingham Academy of Medicine). Birmingham News, *A-28:* 1967.
2. Kuo, P. T., Feng, L., Cohen, N. N., Fitts, W. T., and Miller, L. D.: Dietary carbohydrates in hyperlipemia (hyperglyceridemia); hepatic and adipose tissue lipogenic activities. Am. J. Clin. Nutrition, *20:* 116, 1967.
3. Macdonald, I.: Dietary carbohydrates in normolipemia. Am. J. Clin. Nutrition, *20:* 185, 1967.
4. Hodges, R. E., Krehl, W. A., Stone, D. B., and Lopez, A.: Dietary carbohydrates and low cholesterol diets: effects on serum lipids of man. Am. J. Clin. Nutrition, *20:* 198, 1967.
5. Ostrander, L. K., Neff, B. J., Block, W. D., Francis, T., Jr., and Epstein, F. H.: Hyperglycemia and hypertriglyceridemia among persons with coronary heart disease. Ann. Int. Med., *67:* 34, 1967.
6. Tzagournis, M., Seidersticker, J. F., and Hamwi, G. J.: Serum insulin, carbohydrate, and lipid abnormalities in patients with premature coronary heart disease. Ann. Int. Med., *67:* 42, 1967.
7. Yudkin, J.: Dietetic aspects of atherosclerosis. Angiology, *17:* 127, 1966.
8. Kingsbury, K. J.: The relation between glucose tolerance and atherosclerotic vascular disease. Lancet, *2:* 1374, 1966.
9. Albrink, M. J.: Carbohydrate metabolism in cardiovascular disease. Ann. Int. Med., *62:* 1330, 1965.
10. Epstein, F. H.: The epidemiology of coronary heart disease. J. Chron. Dis., *18:* 735. 1965.
11. Cheraskin, E., Ringsdorf, W. M., Jr., Setyaadmadja, A. T. S. H., and Barrett, R. A.: Effect of carbohydrate supplements upon the height of the T wave in Lead I. Angiology, *19:* 225, 1968.
12. Ch'en, T.-C., Chang, Y-S., Pai, M-Y., Hsu, Y-S., and Hwang, W.: Glucose-loading ECG test in the diagnosis of coronary atherosclerosis. Chinese M. J., *81:* 277, 1962.
13. Ostrander, L. D., and Weinstein, B. J.: Electrocardiographic changes after glucose ingestion. Circulation, *30:* 67, 1964.
14. Ostrander, L. D.: The effect of glucose ingestion upon electrocardiograms in an epidemiological study. Am. J. M. Sc., *251:* 399, 1966.
15. Kilinskii. E. L., and Vysokii, F. F.: Production of electrocardiographic changes in sugar tests. Fed. Proc. (Translation Suppl.), *25:* T794, 1966.
16. Cheraskin, E., and Ringsdorf, W. M., Jr.: Electrocardiography and carbohydrate metabolism. I. P-wave length (Lead I) in presumably healthy young men. J. M. A. Alabama, *38:* 1011, 1969.
17. Somogyi, M.: Determination of blood sugar. J. Biol. Chem., *160:* 69, 1945.
18. Nelson, N.: A photometric adaptation of the Somogyi method for the determination of blood sugar. J. Biol. Chem., *153:* 375, 1944.
19. Cheraskin, E., Ringsdorf, W. M., Jr., and Setyaadmadja, A. T. S. H.: The use of a microscope for electrocardiographic measurement. Exper. Med. & Surg., *23:* 369, 1965.
20. Dubos, R.: Mirage of Health, p. 100. New York, Harper and Brothers, 1959.