

CHANGES OF THE HEART MUSCLE DUE TO CHRONIC FLUOROSIS

Part I

ELECTROCARDIOGRAM AND CARDIAC X-RAYS IN INHABITANTS OF A HIGH FLUORIDE ZONE

by

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Studies on the influence of fluoride upon the heart are sparse. In reviewing the literature, clinical data pertaining to the cardiovascular system in acute fluoride toxicosis were presented by Tappeiner (1, 2), Roholm (3, 4) and Lerner (5), pharmacological data by DeNito (6), Gottdenker and Rothberger (7, 8) and Chenowith (9) and electrocardiographic studies by Chatel (10) and Lepeschkin (11), but no systematic studies on the involvement of the heart in fluoride toxicosis are available. Dental fluorosis occurs in chronic fluoride poisoning but not in acute fluoride toxicosis.

Sodium fluoride in drinking water has recently been advocated for the prevention of dental caries. A study of the effect of chronic fluoride toxicosis upon the heart was therefore of interest.

The author has conducted electrocardiographic and roentgenologic examinations in Shionoe village, Kagawa Prefecture, in 1952, and in Odani village, Sanyo town, Okayama Prefecture, in 1953. Many instances of myocardial damage were observed electrocardiographically; other cases, exhibiting hypertrophy and dilatation of the cardiac chambers, were recorded roentgenographically.

Methods and Procedures

In 1952, the author examined electrocardiograms and X-rays of 35 residents (25 children and 10 adults) of Shionoe village, Kagawa Prefecture, and of four adults of Odani village, Okayama Prefecture, in 1953. The electrocardiographic examinations were carried out with standard limb leads, and roentgenologic examinations were performed by 2m, 58KV, 30 m^A. The fluoride content of drinking water was determined by the aluminum hematoxylin method (12). The mottled enamel of the inhabitants who were examined was classified by Kawahara (13).

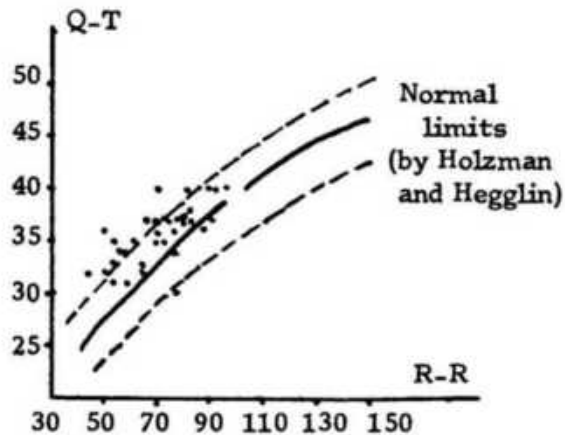
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Results

Many of the inhabitants of the high fluoride zone had myocardial damage. A higher incidence of myocardial damage occurred in "mottled-enamel" children than in those not so affected. The Q-T interval was prolonged frequently in the mottled-teeth subjects (Fig. 1).

Fig. 1

Q-T Interval in 35 Residents with Mottled Teeth



Electrocardiogram and X-Ray Findings in High Fluoride Okayama

Four residents with mottled enamel and marked limitation in various joints of Odani village, Sanyo town, Okayama Prefecture, were selected for the roentgenological studies. The roentgenologic bone changes were identical with those seen in chronic fluoride poisoning. Patients whose movement had become restricted because of the skeletal changes were eventually unable to move about without aid. Usually they had no general complaints, except for periodic mild rheumatic pains. The fluoride content of their drinking water ranged from 6 to 13 ppm. The patients had been drinking this water daily for more than 10 years. The following are the cardiological findings in the four cases:

1) C. T., a 57 year old male had a blood pressure of 140/100. The fluoride content of his drinking water was 8.5 ppm.

Electrocardiogram: R-R = 0.95 second, $R_1 = 0.6$ mV, $R_2 = 0.7$ mV, $R_3 = 0.2$ mV, $T_1 = 0.5$ mV, $T_2 = 0.7$ mV, QT = 0.4 second, QRS = 0.14 second, and was characterized by a tall, slender R wave in lead I-II and the wide, slurred S wave, i. e. a pattern indicative of Wilson's right bundle branch block.

X-Ray picture: (Moritz' measurement) Lb (Lungenbasis) = 26.0 cm, Mr (Mediandistance right) = 5.8 cm, Ml (Mediandistance left) = 10.2 cm, therefore

Tr (Transverse diameter) = 16.0 cm, L (Longitudinal diameter) = 16.7 cm, therefore L-Tr = 0.7 cm, uQ (unterer Querabstand) = 5.9 cm, Br (Querdurchmesser) = 10.5 cm, therefore Tr-Br = 5.5 cm, Bh (height of arch) = 2.3 cm.

This X-ray established evidence of considerable dilatation of the right and left ventricles.

2) E. F., a 54 year old male with a blood pressure of 110/90. The fluoride content of the drinking water was 8.5 ppm.

Electrocardiogram: R-R = 0.75 second, $R_1 = 0.5$ mV, $R_2 = 1.3$ mV, $R_3 = 0.8$ mV, $T_1 = 0.25$ mV, $T_2 = 0.4$ mV, $T_3 = 0.15$ mV, and P wave showed notched, pointed elevation (0.3 mV) and broad (0.12 second) in lead II-III. This electrocardiogram showed a marked pulmonary P with prolonged P-R interval (0.23 second).

X-ray picture: Lb=2.65 cm, Mr=3.9 cm, M1=10.8 cm, Tr-14.7cm, L=16.7 cm, L-Tr=2.0 cm, oQ=3.7 cm, uQ= 6.5 cm, Br= 10.2 cm, Bh=2.2 cm. This X-ray showed evidence of marked dilatation of the left ventricle figure.

3) K. F., a 46 year old male. Fluoride content of water was 6.0 ppm, blood pressure 130.

Electrocardiogram: R-R = 0.8 second, $R_1 = 2.0$ mV, $R_2 = 1.2$ mV, $R_3 = 0.5$ mV, $T_1 = 0.5$ mV, $T_2 = 0.3$ mV, $T_3 = 0.3$ mV, $S_3 = 1.3$ mV. This EKG showed a marked left axis deviation with elevated S-T in lead I and slight prolonged P-R interval (0.2 second).

X-Ray picture: Lb = 25.5 cm, Mr = 5.5 cm, M1 = 6.1 cm, therefore, Tr = 11.6 cm. This X-ray revealed evidence of dilatation of the right ventricle.

4) S. H., a 29 year old female. Fluoride content of water was 13.0 ppm. Her electrocardiogram: $R_1 = 0.7$ mV, $R_2 = 1.4$ mV, $R_3 = 1.5$ mV, $T_1 = 0.2$ mV, $T_3 = 0$, $S_1 = 0.6$ mV, P-R = 0.2 second, and P showed pointed elevation (0.3 mV) indicative of right ventricular strain with pulmonary P and prolonged P-R interval. The X-ray picture: Lb = 22.0, Mr = 3.9 cm, M1 = 6.6 cm, therefore, Tr = 10.5 cm, L = 11.8 cm, oQ = 5.3 cm, uQ = 3.7 cm, therefore, Br = 9.0 cm. Bh = 1.2 cm. This X-ray is normal.

(The original paper contains a tabulation of all EKG changes in 20 children with dental fluorosis and 16 without mottling. Editor)

Discussion

The electrocardiograms showed marked myocardial damage in the two cases residing in the high fluoride areas and the x-rays provided evidence of greater dilatation of heart in local inhabitants than in individuals elsewhere.

According to investigators at the Iowa Agricultural Experiment Station (15,16), studies on the effect of fluorides upon growth and reproduction of albino rats yielded the following conclusions: "The toxic effects produced by sodium fluoride vary directly with the amount of calcium salts in the ration"; "the toxic effects of calcium fluoride are much less marked than those of sodium fluoride". Own observations showed that the myocardial damage was proportional to the fluoride content of drinking water and to the extent of mottled enamel. Our data have been confirmed by laboratory experiments which will be published later.

Larner (5) observed that the heart and brains appear to be organs which are very susceptible to fluoride-containing compounds. The authors, in their experiments on chronic fluoride poisoning as well as in inhabitants of the high fluoride zone, observed myocardial damage, bundle branch block and pulmonary P and such pathological changes as myocarditis and myocardial degeneration.

In a survey of "Aso-Volcano" Disease, Hatano (18) quoted Okinaka (17) who had performed electrographic and X-ray examinations in inhabitants in Shikimi village, Kumamoto Prefecture and found right bundle branch block and dilatation of the ventricles. The author (19) surveyed the same district in 1953 and obtained the same results, but the myocardial damage of the inhabitants in this district was less severe than in the high fluoride region of Kagawa and Okayama Prefecture. The fluoride content (0.1 to 1.1 ppm) of the well water of the Aso-Volcano district was lower than in both high fluoride areas. Okinaka attributed the myocardial damage to an endocrine disorder associated with the parotis gland. However, the author considers the high fluoride content of drinking water the cause.

Summary

1) The author examined inhabitants of a high fluoride zone (Shionoe village, Kagawa Prefecture, and Odani village, Sanyo town, Okayama Prefecture). In residents of these zones, greater myocardial damage was detected electrocardiographically and dilatation of the cardiac silhouette roentgenographically than in nonfluoride areas.

2) The myocardial damage appears to be related to the high fluoride content of drinking water.

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Bibliography

1. Tappeiner, H.: Zur Kenntniss der Wirkung des Fluornatrium. Arch. f. exper. Path. B. 25:203, 1889.
2. Tappeiner, H.: Mittheilung über die Wirkungen des Fluornatrium. Arch. f. exper. Path. B. 27:108, 1890.
3. Roholm, K.: Fluorschädigungen. Arbeitsmedizin in Abhandlungen über Berufskrankheiten und deren Verhütung, Heft 7, 1937.
4. Roholm, K.: Fluorvergiftung bei Kryolitharbeitern. Artiv. Für Gewerbepathologie und Gewerbehygiene B. 7:255, 1937.
5. Larner, J.: Toxicological and Metabolic Effects of Fluorine-Containing Compounds. Industrial Medicine and Surgery. 19:535, 1950.
6. DeNito, G.: Ricerche Farmacologiche Sul Fluoruro Disidio. Riv. di Path. Sper. 3:294, 1928.
7. Gottdenker, F. and Rothberger, C.J.: Über die Wirkung von Natriumfluorid auf das Froschherz. Arch. f. Exper. Path. u. Pharmakol. B. 179:24, 1935.
8. Gottdenker, F. and Rothberger, C.J.: Über die Wirkung von Natriumfluorid auf das Warmblüterherz. Arch. f. Exper. Path. u. Pharmakol. B. 179:38, 1935.
9. Chenowith, M.B. and Gilman, A.: Studies on the Pharmacology of Fluoroacetate. J. Pharmacol. Experimental Therap. 82:90, 1946.
10. Chatel, A. De: Versuch einer Analyse der Pathologischen Veränderungen des Zwischenstückes und der Endschwankung des Electrocardiogramms auf Grund von Lokalen Ableitungen. Ztschr. f. d. ges. Exper. Med. B. 98:389, 1936.
11. Lepeschkin, E.: Modern Electrocardiography V, I., 1951.
12. Okuno, H.: A New Colorimetric Method for Fluorine Determination. J. Chem. Soc. Japan 63:23, 1943.
13. Kawahara, H.: The New Method of Classifying Mottled Teeth Based on Fluorine Content in Drinking Water. A Monthly Record of Dental Science V. 52, No. 7, 1952.
14. Hamamono, E., Fujiwara, H.: On Bone Changes Observed in Residents of High Fluorine Zone. Proceeding of the Japan Academy 30:53, 1954.
15. Iowa Agric. Exper. Station Report for Year Ending June 30, 1928, p. 29.
16. Iowa Agric. Exper. Station Report for Year Ending June 30, 1929, P. 29.
17. Okinaka, S.: Aso-Volcano Disease. Japanese Medical Journal 1405:3, 1951.
18. Hatano, S.: The Study of Aso-Volcano Disease. Japanese Path. Journal. 33:332, 1944.
19. Takamori, T., Okushi, I.: Aso-Volcano Disease. Part III (in preparation).
20. Smith, M.C.: J. Dent. Res., 15:281, 1936.
21. Smith, M.C., Lantz, M.E. and Smith, H.V.: J.A.D.A. 22, 1935.
22. Churchill, H.V.: Occurrence of Fluorides in some Waters of the United States. Jour. Ind. and Eng. Chem. 23:996, 1931.
23. Brandl, J. and Tappeiner, H.: Ztschr f. Biol. 28, 1891.
24. Tamai, I.: The Journal of the Wakayama Medical Society 3:23, 1952.