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Observations of Two-Dimensional (2D) Echocardiograms in Patients with Fluorine-Associated Aortic Sclerosis

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Abstract Forty-six patients with endemic fluorosis were assigned to 4 subgroups based on their age and then received echocardiograms that were compared with echocardiograms of 46 healthy cases in a region affected by fluorosis and 46 healthy cases in a region unaffected by fluorosis via observations; a preliminary exploration was made on the changes of 2D echocardiograms of patients with endemic fluorosis. Results demonstrated the following: (1) The aortic wall was thickened for all patients (100%) in the fluorosis group, the thickness being within 7.5–9.8 mm; the thickening occurred in the periphery of aortic wall and the thickness was irrelevant to age and disease course; (2) Moderate or above echo intensification of aortic wall occurred in 37 cases from the fluorosis group (79.8%) and only 4 cases from the control group I (8.7%); (3) For the fluorosis group, the pulsating amplitude of aortic root measured by M-mode ultrasound was less than that for the control groups; (4) For the 31–40 year old subgroup and the 41–50 year old subgroup of the fluorosis group, the thickness of the left ventricular posterior wall was greater than that for the control groups; there was no difference in terms of atria, ventricles and other items. The results of the current study suggested that: endemic fluorosis may lead to aortic sclerosis which would significantly precipitate and worsen the transformation of sclerosis to calcification for the main arteries; therefore, the concept of fluorine-associated aortic sclerosis was proposed and discussions on the pathological and physiological mechanism of fluorine-associated aortic sclerosis were made.

Key words 2D echocardiogram; fluorine-associated aortic sclerosis; endemic fluorosis

At present, domestic reports about the research on cardiovascular injury caused by fluorosis are scant. In 1986, the authors performed echocardiography on 46 patients with endemic fluorosis and discovered the manifestations of aortic sclerosis such as changes of aortic inner diameter, aortic wall thickening, intensified echoes, and reduced movement. A preliminary summary on the echocardiographic changes of patients with fluorosis was made in order to probe into the effect of fluorides on great vessels of the heart.

Data and Methods

I. Objects: Seventy-one inpatients were chosen from 403 cases with skeletal fluorosis [(1)] from a region seriously affected by fluorosis due to high fluorine content in drinking water—Hongshawo Affected District, Zhangye City, Gansu Province; of the above 71 patients, 46 patients free of systemic diseases and fluorine-related cardiovascular diseases and with complete data were selected for examination by 2D echocardiogram (ZDE [sic: 2DE]) and M-mode echocardiogram (M-mode ultrasound). In the above affected region, the content of fluorine in drinking water was between 3.0 and 10.0 mg/L, the incidence of dental fluorosis reached up to 85.4%, the incidence of skeletal fluorosis reached up to 31.9% and patients with grade-III fluorosis accounted for 8.9% of the fluorosis patients. For these 46 patients (20 males and 26 females), the content of fluorine in drinking water was as follows: 3.0 mg/L for 4 cases (8.7%), 3.5 mg/L for 9 cases (19.6%), and 10.0 mg/L for 33 cases (71.7%). Among the 46 cases, anteroposterior films of the heart revealed 40 cases with aortic sclerosis (86.9%) and 31 cases with calcification of aortic bulb (67.4%). The clinical grading for the different age groups among these 46 cases is shown in Table 1.

For the control group I, 46 adults were chosen from the same affected region, who were free of skeletal fluorosis and had comparable age and gender to the fluorosis group. For the control group II, an additional 46 healthy adults were chosen from a region unaffected by fluorosis, where the content of fluorine in drinking water was 0.68 mg/L and other environmental factors were comparable to those of the affected region.

Table 1 Relation between clinical grading and age for 46 cases with fluorosis

Age subgroup (years old)	Clinical grading		
	I	II	III
31-40	5 (10.9)	5 (10.9)	2 (4.3)
41-50	5 (10.9)	5 (10.9)	4 (8.7)
51-60	4 (8.7)	8 (17.4)	5 (10.9)
51(sic)-70	0	2 (4.3)	1 (2.2)
Total	14	20	12

II. Methods: An ADR4000S/L ultrasonograph (United States) was used, and mechanical sector scanning was performed; the probe frequency was set to 3.0 MHz and the sector was set to 90°; a domestically produced model XJY-6A cardiac function diagnostic apparatus was used. Examinees assumed a left supine position; ten routine tomographic sections were examined by 2DE, and five routine precordial regions were examined by M-mode ultrasound. Real-time video and photos were taken for concurrent measurement and analyses. In the examination, the gain was kept to a minimum in order to distinctly display the chest wall, pericardium, heart wall and endocardium. The thickness of aortic wall was measured over the section along the longest diameter of the left ventricle. The aortic root was displayed distinctly; upper and lower margins of light belts on anterior and posterior walls were selected on the distinct boundaries on both sides; the posterior wall was included in the upper margin of the atrial wall, and the anterior wall included the lower margin of the right ventricular outflow tract. For the fluorosis group, the reflected light of the aortic wall was intensified and the light belt was widened; thus the measured data became relatively larger.

Analyses of Results

Results of 2DE for the fluorosis group and control groups are shown in Table 2.

Table 2 Observation results of 2DE in 46 cases in fluorosis group and [cases] in control groups ($\bar{x} \pm SD$) Unit: mm

Group	Age (years old)	No. of cases	Aortic inner diameter	Thickness of aortic wall		Opening spacing of aortic valve	Thickness of interventricular septum	Thickness of left ventricular posterior wall
				Anterior wall	Posterior wall			
Fluorosis group	31-40	12	26.08 ± 2.02	8.75 ± 1.91	7.75 ± 1.76	18.33 ± 2.71	9.08 ± 1.24	9.08 ± 0.90
	41-50	14	27.16 ± 1.64	8.77 ± 1.09	8.38 ± 1.26	16.15 ± 1.28	9.62 ± 1.05	9.46 ± 0.88
	51-60	17	27.28 ± 2.56	9.39 ± 0.92	8.61 ± 1.24	17.28 ± 1.90	9.94 ± 1.39	9.67 ± 1.08
	61-70	3	25.33 ± 1.53	9.33 ± 1.15	8.67 ± 1.15	18.33 ± 2.89	9.33 ± 0.58	9.67 ± 0.58
Control group (1)	31-40	12	26.75 ± 1.71	4.42 ± 1.08	3.92 ± 0.90	16.08 ± 1.08	8.58 ± 0.67	8.25 ± 0.87
	41-50	14	28.92 ± 1.75	4.61 ± 1.04	4.46 ± 0.97	16.38 ± 1.94	9.23 ± 0.73	8.85 ± 0.67
	51-60	17	28.61 ± 1.94	4.83 ± 1.50	4.50 ± 1.42	16.11 ± 2.25	9.50 ± 0.51	8.94 ± 0.42
	61-70	3	30.33 ± 2.08	4.33 ± 0.58	4.33 ± 0.58	17.33 ± 2.52	8.67 ± 0.58	9.0 ± 0.00
Control group (2)	31-40	12	28.17 ± 1.19	3.50 ± 0.52	2.83 ± 0.39	16.25 ± 1.14	8.33 ± 0.56	7.58 ± 0.51
	41-50	14	29.46 ± 2.26	3.31 ± 0.63	3.08 ± 0.49	17.08 ± 1.89	8.54 ± 0.78	8.38 ± 0.87
	51-60	17	30.83 ± 1.20	3.67 ± 0.49	3.17 ± 0.38	18.22 ± 1.35	9.28 ± 0.57	9.33 ± 0.59
	61-70	3	31 ± 1.00	4.00 ± 0.00	3.00 ± 0.60	15.67 ± 1.15	8.67 ± 0.58	8.33 ± 1.15

Aorta: All patients (100%) in the fluorosis group had thickened aortic wall, the thickness being 7.5–9.0 mm, significantly greater than the normal value [(2)] and the values in control groups ($P < 0.01$). The thickening of the aortic wall occurred in the periphery, and was irrelevant to age and disease course. The aortic inner diameter for the fluorosis group was smaller than that for the normal control group ($P < 0.01$). Results of the current study demonstrated that: the thickening of the aortic wall due to fluorosis holds an important position in chronic fluorosis [(3)]. Moderate and above echo intensification of aortic wall occurred in 37 cases in the fluorosis group (79.8%), versus 4 cases in the control group I (8.7%), and no cases in the control group II. As for the pulsating amplitude of aortic root measured by M-mode ultrasound, it was 5.91 ± 1.40 for the fluorosis group, significantly smaller than that for the control group I (7.33 ± 2.37) and the control group II (9.68 ± 1.07) ($P < 0.01$).

Heart wall and heart cavity: Thickness of the left ventricular posterior wall for the 31–40 year old subgroup and 41–50 year old subgroup of the fluorosis group was greater than that for the control group II ($P < 0.01$); thickness of the interventricular septum did not differ significantly among the three groups, and there was no difference in terms of atria and ventricles and other items.

Discussion

Regarding the changes of main arteries due to endemic fluorosis, it was suggested in this article that the long-term accumulation of fluorides in the bodies of patients with skeletal fluorosis in a seriously affected region may cause remarkable cardiovascular injury, leading to thickening, sclerosis and calcification of aortic wall.

The content of F^- in the blood of patients with endemic fluorosis is increased, thus a large amount of fluorine compounds and complexes may accumulate in the bones, tendons, ligaments, interosseous membranes and skeletal muscles to cause lesions, and fluorides may also enter the aortic wall. Based on what was reported by Call *et al*, of all soft tissues, the aorta had the highest content of fluorides (125 ppm), which may be attributed to the selective affinity of F^- to tissues. Some researchers consider fluorides to be an indispensable factor for calcification, and that the long-term uptake of excess fluorides may result in an accumulation of large amounts of calcium salts in the body's soft tissues, and that fluorides accumulating in the aortic wall may bind with Ca++ and other cations in serum to form fluorapatite, which would interfere with the equilibrium between Ca in bones and Ca in blood through parathyroid metabolism, so that Ca++ would settle down in the arterial elastic layer and its periphery to form plaque-like intimal thickening or fibrotic lesions, making the aortic wall harden and thicken, manifesting as ultrasound echo intensification and echo belts with increased density. The data in this article agree with Call's judgment, and it is inferred that the pathological change of fluorine-associated aortic sclerosis may be attributed to degeneration, sclerosis and calcification of the middle elastic fibrous layer.

As for the differential diagnosis of aortic sclerosis, persons over the age of 40 generally have aortic atherosclerosis of different severities[(4)]; persons over the age of 60 would most often have calcification, while persons with serious fluorosis over the age of 40 would have both sclerotic and calcification changes, manifesting as a thickened aortic wall with intensified echoes and dense echo-intensified belts on the aortic wall; additionally, age-related aortic sclerosis would be accompanied most often by increased aortic inner diameter. The aforesaid, combined with the patients' epidemiological information, helps to make the differentiation.

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