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Natural History of Disease in Atomic Bomb Exposed Twins in Hiroshima —Findings of Chest X-Ray and Electrocardiogram—*)

Yukio SATOW[1)], Kiyokazu OHMAE[1)], Naomasa OKAMOTO[1)], Tsutomu ABE[2)] and Shoji WATANABE[3)]

1) *Department of Geneticopathology, Research Institute for Nuclear Medicine and Biology, Hiroshima University, Hiroshima 734, Japan*
2) *Dept. of Internal Medicine, Recearch Institute for Nuclear Medicine and Biology, Hiroshima University, Hiroshima 734, Japan*
3) *Dept. of Epidemiology and Social Medicine, Research Institute for Nuclear Medicine anb Biolgy, Hirohima University, Hiroshima 734, Japan*

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ABSTRACT

The subjects of this study are mainly pairs of monozygotic twins, one of whom w s exposed to the atomic bomb and the other not exposed, and the natural history of the diseases of these twins was analyzed to find out genetic and environmental factors of the diseases and some biological effect of the atomic bomb exposure or other. In this study, 13 pairs of monozygotic and 5 pairs of dizygotic twins and other 34 cases of non-twins were examined by means of heart and lung X-ray films and electrocardiograms. The results suggest that most of the monozygotic twins show the similar findings of chest X-ray films, though their electrocardiograms have a tendency to deviate to the left in the QRS axis. These findings will not be enough to clear up the relation between the atomic bomb exposed and the abnormal electrocardiograms.

INTRODUCTION

The purpose of this study is to make a general medical and genetic investigation on the atomic bomb exposed twins to look for some biological effect of atomic bomb exposure and to provide data that are useful for the health managemant of atomic bomb survivors. Subjects are mainly pairs of monozygotic twins, one of whom was exposed to the atomic bomb and the other not exposed. As for pairs, both of whom were exposed, an investigation is also made to see how they have been affected by the difference of enviromental conditions[8)]. They will be grouped with the similar findings to make clear the interrelation of environmental fastors including atomic bomb exposure. In this paper, we are going to show the findings of heart and lung X-ray films and electrocardiograms of some pairs of the exposed mono- and dizygotic twins.

MATERIALS AND METHODS

Exposed twins were picked up by an electronic computer from the master file of atomic bomb survivors in our instituts[7)] and examined clinically and physiologically[10,12)]. Their zygosity diagnoses were also made. The natural history of their diseases was investigated to find out possible late effects of the atomic bomb. Among many check-up points, the values of immnoglobulin M and A[1)] and the height[2)] are considered to be genetically controlled to a considerable extent. On the other hand, the values of immnoglobulin G[1)], serum cholesterol, body weight, blood pressure[3,6)] and electrocardiogram[6)] are considered to be susceptible to both genetic and environmental effects. The concordance or discordance of these values might provide an indicator of the genetic and or environ-

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mental effects.

Total 470 pairs of exposed twins have been found. Among them, 220 pairs of twins are both alive, counting 48 pairs of the other sex and 172 pairs of the same sex. According to Weinberg's method[13] and also considering that the ratio MZ:DZ is about 1.83 : 1 in the Japanese[5], about 112 pairs are assumed to be monozygotic and about 60 pairs dizygotic. The zygosity diagnosis include blood type (ABO, MN and S type), finger prints, PTC test, earwax examination[4]. HLA has been added recently.

In this puper, we show some results obtained from the comparison of the findings of electrocardiograms and chest X-ray films of monozygotic twins with those of dizygotic twins and non-twin controls. Total 13 pairs of monozygotic twins (10 pairs of male and 3 pairs of female aged 18–56), and total 5 pairs of dizygotic twins (3 pairs of male and 2 pairs of female aged 9–79) have been examined.

In addition to these twin groups, another group of 34 cases of non-twins aged from 23 to 74 and with systolic blood pressure of less than 150 mmHg and diastolic blood pressure of 90 mmHg has been also checked up by an eletrocardiogram. The electrocardiograms are taken by Routine 12 Lead.

RESULTS

Findings of the electrocardiograms of monozygotic twins

The values of blood pressure of all pairs of monozygotic twins are within the normal limits

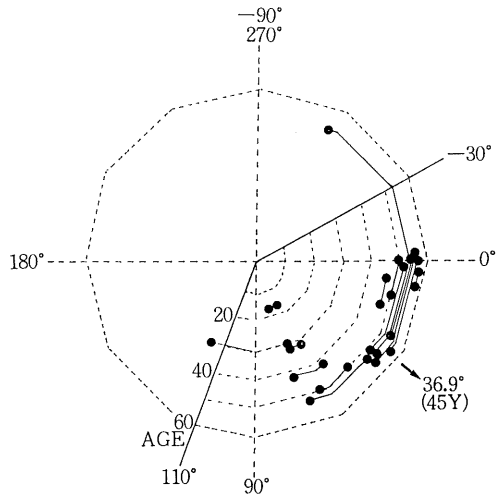

Fig. 1. Schematic drawing combined QRS axis of electrocardiogram with age of monozygotic twins. Between −30° and 110° show normal limit. Over 110° indicate abnormal right axis deviation and under −30°, abnormal left axis deviation. The axis mean is 36.9° at the average of 45, showing tendency to left axis deviation.

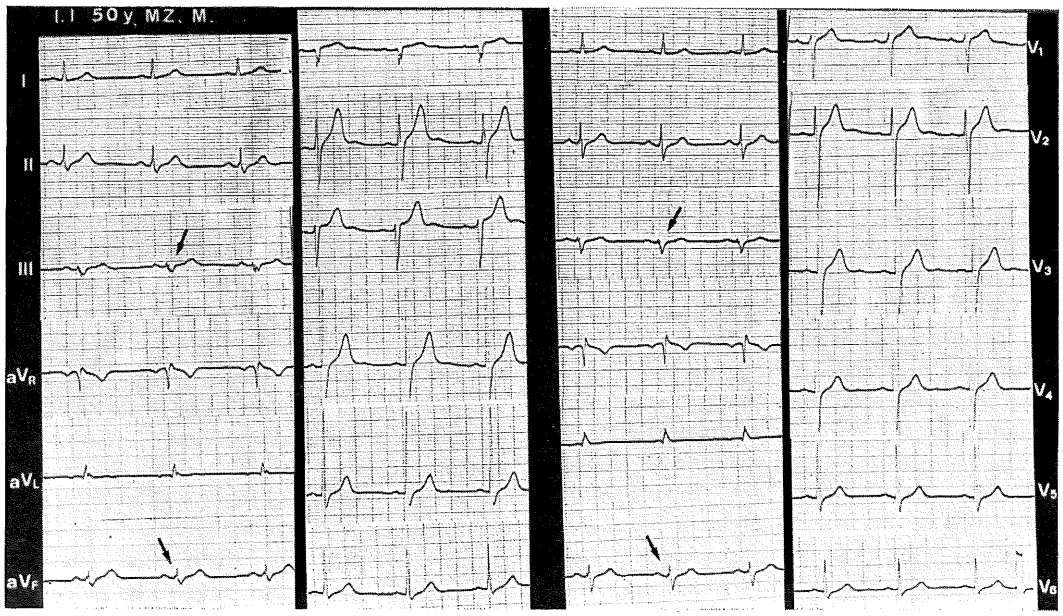

Fig. 2. Electrocardiogram of 50 years old male monozygotic twin sibilings. The pattern PQ-QRS-ST complexes are similar in each Lead of sibiling respectively. The allow show notchs on R waves.

Table 1. Some physiological and clinical findings of monozygotic twins. In the column of A-bomb, the distances from the hypocenter of the atomic aomb or the day when entered to the Hiroshima City after atomic bomb are shown. The findings of arteriosclerosis of lungs and notch on R wave in electrocardiogram are observed in many twin sibilings.

Case	Sex	Age	Height cm	B.W kg	B.P	Chest X-ray findings	Heart Lung ratio %	QRS Axis	Notch on R wave	Order of Delivery	A-Bomb
1	M	18	173.0	62.0	120— 60	Slight fibrosis	46	72	II, III, V_1	1	not exposed
			172.0	63.0	130— 70	〃	44	75	II, III	2	not exposed
2	M	30	167.0	81.0	122— 75	Arteriosclerosis	49.1	68	(−)	1	1.8 km
			163.8	73.0	130— 70	〃	45	120	(−)	2	1.5 km
3	M	31	160.0	50.0	86— 50	Arderiosclerosis	42.5	68	(−)	1	3.0 km
			161.2	63.0	120— 80	〃	44	67	(−)	2	3.0 km
4	M	42	160.0	60.0	130— 85	Arteriosclerosis	45	72	III, V_1	1	not exposed
			160.0	63.0	130— 90	〃	44	57	III	2	not exposed
5	M	48	165.0	78.0	120— 90	Arteriosclerosis LVH	54	7	I, III, aV_L	1	5 days after entrance
			165.0	74.0	120— 90	〃	54	18	I, III, aV_L	2	5 days after entrance
6	F	50	145.5	39.3	130— 70			49	(−)	1	not exposed
			145.5	47.9	120— 60			64	(−)	2	next day entrance
7	M	50	164.0	58.0	160— 90	Arteriosclerosis Emphysema	50	0	III, aV_F	1	3.0 km
			160.5	53.5	152—102	〃	47	14	III, aV_F	2	net exposed
8	M	50	151.0	52.0	144— 80	Arteriosclerosis LVH	44.8	42	I	1	2 days after entrance
			154.3	54.6	138— 90	〃	50	−64	I	2	2.0 km
9	M	51	165.0	55.0	130— 85	Arteriosclerosis Emphysema	44	70	III, aV_F, aV_L	1	4.0 km
			163.0	65.0	135— 75	〃	47	40	III, aV_F, aV_L	2	4.0 km
10	F	52	140.6	44.5	120— 80	Arteriosclerosis	53	30	aV_L	1	2.5 km
			142.5	44.2	160— 84	〃	48	0	III, aV_L	2	2.0 km
11	F	52	141.7	58.5	136— 68	Arteriosclerosis	47	−3.5	I,III,aV_L,aV_F	1	2.3 km
			160.5	71.5	174— 96	〃	46	45	(−)	2	2.5 km
12	M	53	162.5	70.0	136— 86	Arteriosclerosis	50	35	I,III,aV_F,aV_L	1	1.5 km
			163.2	60.2	112— 82	〃	50	0	I, aV_F	2	not exposed
13	M	56	172.0	60.0	130— 88	Arteriosclerosis	56	5	III, AV_F	1	not exposed
			172.0	64.0	130— 80	〃	54	9	II	2	The day entrance
Mean		44.8	159.6	60.2	131.3—79.8		48.1	36.9			

except in Cases 7 and 11(Table 1). All the pairs are exactly alike each other in the pattern of their electbocardiogram, that is, such intervals as PQ, QRS and ST in each pair are almost the same and so is the voltage. The QRS axes of their electrocardiograms are shown in Tab. 1 and Fig. 1. The axis mean is 36.9°. As an example of these similarties, typical patterns of

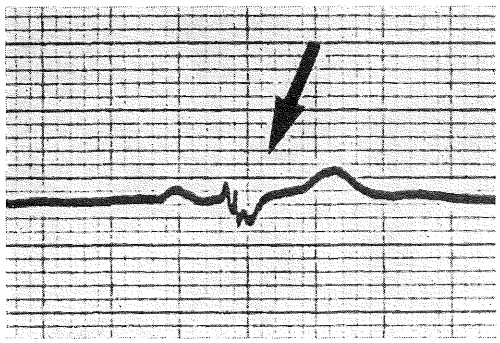

Fig. 3. High magnification of wave notch on Lead III, one of twins in Fig. 2, Case 7.

the twins' electrocardiograms are shown in Figs. 2 and 4 (Cases 7 and 5). Table 1 shows that another distictive feature seen in many cases of the monozygotic twins is the noth on the QRS wave especially in the combination of Lead I and aV_L and/or Lead III and aV_F (Figs. 2, 3, 4 and 5).

Findings of the heart and Lung X-ray films of monozygotic twins

Chest X-ray films show us that a pair of monozygotic twins are very much alike each other both in the external form of the heart and in the ratio of heart to lung in most cases. The heart/lung ratio of over 50% is seen only in Cases 5, 10 and 13 (Table 1). We also notice that the left ventricular hypertrophy is seen only in Cases 5 and 8 (Table 1), and that the protruding aortic arch and the clear left side line

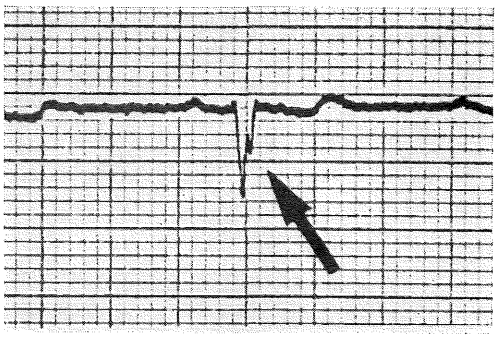

Fig. 5. High magnification of wave notch on Lead III, one of twins in Fig. 4, Case 5.

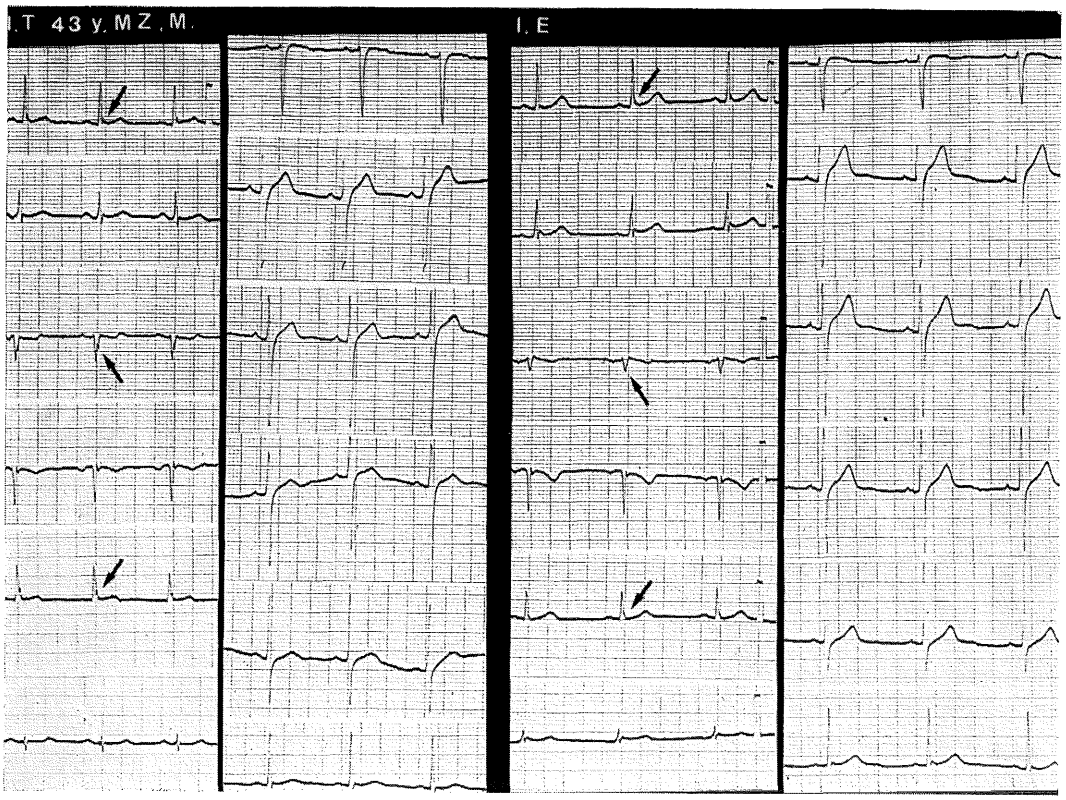

Fig. 4. Electrocardiogram of 48 years old male monozygotic twin of Case 5 in Table 1. The notchs on R waves are seen on the same Lead in each twin.

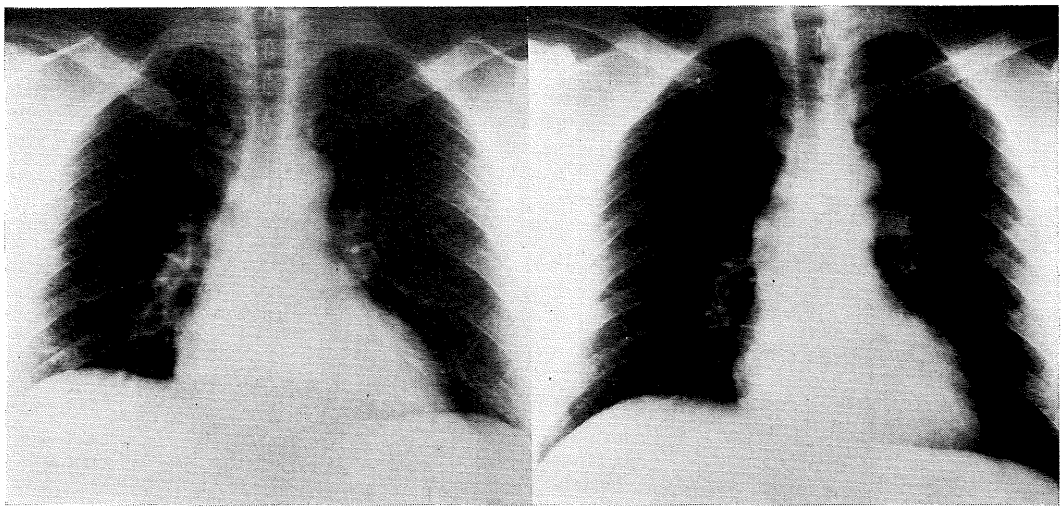

Fig. 6. Chest X-ray films of 48 years old male monozygotic twin, Case 5 in Table 1. In both sibilings the findings of arteriosclerosis and left ventricular hypertrophy are observed.

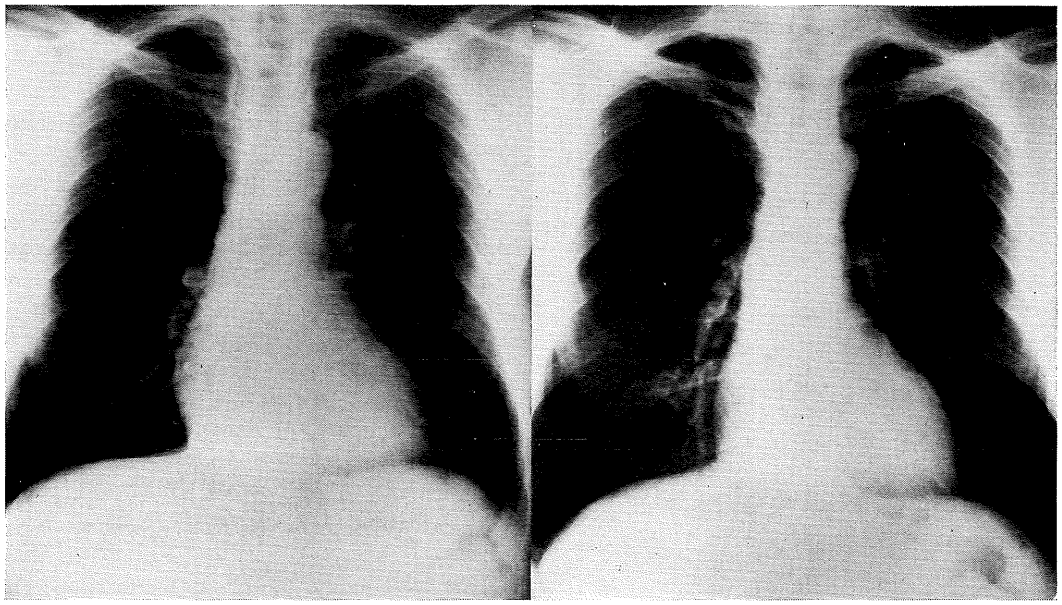

Fig. 7. X-ray findings of 50 years old male monozygotic twin, Case 7 in Table 1. In both, the clear left side line of the decending aorta and protruded aortic arch are seen showing arteriosclerosis. Emphysema are also noticed in both sibilings.

of the thoracic and abdominal arteries that indicate arteriosclerosis are seen in almost all cases (Figs. 6 and 7).

Findings of the electrocardiograms of dizygotic twins

In all pairs of dyzygotic twins, they do not resemble each other in the QRS-ST-T complexes. The blood pressures are within the normal limits except in Case 5 (Table 2). The QRS axis mean is 65.4° (Fig. 8). As for the notch on R wave, it is seen on each pair of the twins in Cases 2 and 4 and on one of the pair in Cases 1 and 5. Case 3 shows no notch on R wave (Table 2).

Findings of the heart and lung X-ray films of dizygotic twins

As shown in Table 2, the chest X-ray films do not show the arteriosclerotic figure of the aortic

Table 2. Findings of dizygotic twins. Discordances of the findings of chest X-ray and notch on R wave of twin sibilings are noticed.

Case	Sex	Age	Height cm	B.W kg	B.P	Chest X-ray findings	Heart Lung ratio %	QRS Axis	Notch on R wave	Order of Delivery	A-Bomb
1	M	9	127.0	24.2	100—40	n. p	44	84	(−)	1	not exposed
	M		124.5	24.0	75— 0	n. p	48	78	aV_L, V_1	2	not exposed
2	F	15	157.0	49.0	100—70	LVH	51	−3	III, V_1	1	not exposed
	F		153.0	49.5	100—60	n. p	44	54	III, aV_F, V_1	2	not exposed
3	M	32	167.5	65.0	130—80	LVH	47	87	(−)	1	not exposed
	M		168.5	59.0	130—80	n. p	40	90	(−)	2	not exposed
4	F	48	148.0	37.0	94—60	emphysema arteriosclerosis	41	83	III, aV_R	1	nex day entrance
	F		149.7	53.7	110—84	fibrosis arteriosclerosis	47	61	III, aV_L	2	1.6 km
5	M	79	157.1	64.0	166—90			55	(−)	1	1.0 km
	M		167.5	57.0	130—80			65	III, aV_F	2	3.0 km
Mean		36.6	151.9	48.2	113.5—64.4		45.2	65.4			

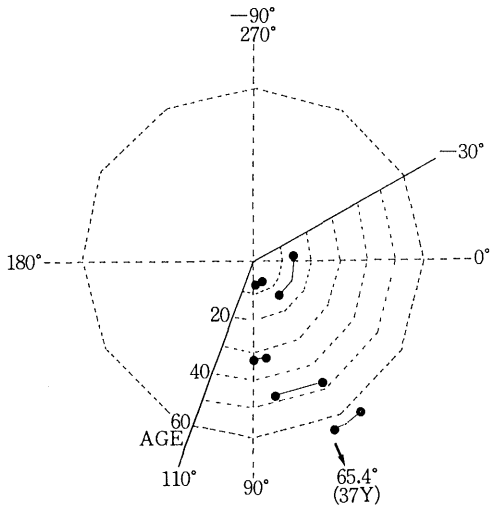

Fig. 8. Schematic drawing combined QRS axis with age of dizygotic twins. The mean of axis is 65.4° at the average age of 37.

arch and descending aorta except in Case 4, where one of the pair shows pulmonary fibrosis and the other emphysema. In Cases 2 and 3, only one of the pair shows the left ventricular hypertrophy. Fig. 9 is a chest X-ray film of Case 4, which shows the difference of the findings of lungs and hearts between the dizygotic twins.

Findings of the electrocardiograms of control group

As shown in Fig. 10, the QRS axis mean measured in this group is 65.9° and its average age is 44.2. This normal group of 34 cases, aged from 23 to 74, shows the normal blood pressure respectively, and no abnormal subjective and objective symptoms are found. An individual pattern of the electrocardiogram is different from one another and no case shows the same QRS-ST-T complex pattern.

DISCUSSION

Comparison of the electrocardiograms in each group

The QRS axis mean in the monozygotic twin group is 36.9° at the average age of 44.8. This mean value of 36.9° is more deviated to the left than 65.9° at almost the same average age of 44.2 in the control group. The QRS axis mean in the dizygotic twin group is 65.4° at the average age of 36.6. This mean value is deviated to the right than that of monozygotic twin and its average age of 36.6 is a little younger than that in the control group. Furthermore the QRS axis mean of the monozygotic twins in Cases 1 to 6 is 61.4° at the average age of 36.5. This value is approximately the same as that of 65.4° at the average age

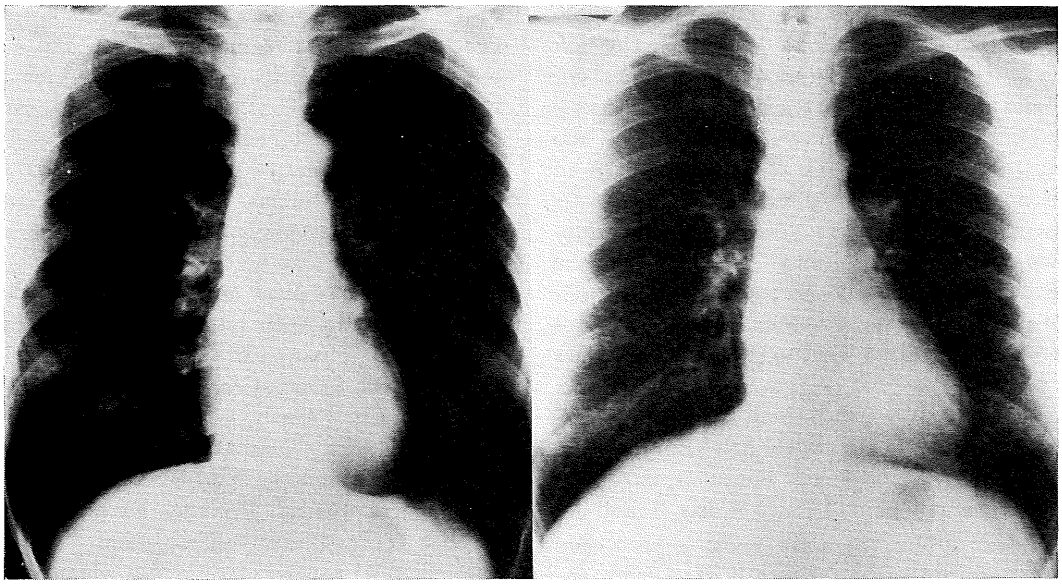

Fig. 9. Chest X-ray film of 48 years old female dizygotic twin sibilings, Case 4 in Table 2. Discordant shape of the heart, emphysema (left) and fibrosis (right) of the lungs are observed.

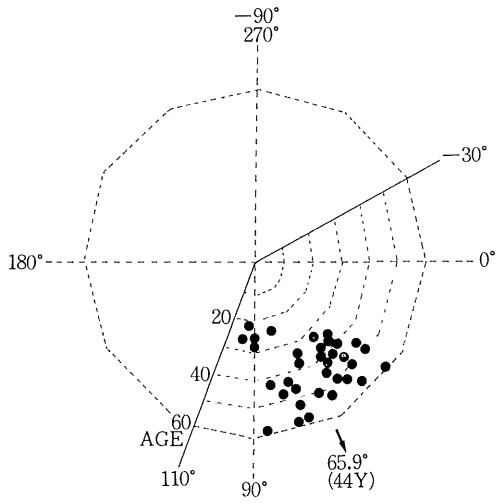

Fig. 10. Schema of QRS axis of electrocardiogram of 34 cases of non-twin control. The mean of axis is 65.8° at the average age 44 years old.

of 36.6 in dizygotic twin group. The QRS axis mean in the control group in Cases 1 to 21 is 66.3° at the average age of 36.9, which is similar to 65.4° at the average age of 36.6 in the dizygotic twin group. From the above we might see that the QRS axis mean in these three mono- and dizygotic twin and control groups is about 65° to the ages of around 35 and that, only in cases of monozygotic twins, the QRS axis mean has a tendency to deviate to the left after 35 years old. As for the similarity of the mono- and dizygotic twin sibilings' QRS axes, monozygotic twin sibilings are alike each other in the QRS axis in Cases 1, 3, 5, 6 and 13 and slightly separated in Cases 2, 4, 7, 8, 9, 10, 11 and 12.

They also resemble each other both in the findings of heart and lung X-ray films and in the heart/lung ratio, but their axes are discordant in many cases as they grow older. These indicate that the QRS axes of the monozygotic twin sibilings are not always similar and have a tendency to deviate to the left although the outer figure of heart shows no difference between them. As for the QRS wave notch, it is observed in 10 cases out of 13 of monozygotic twins. Both of the twin sibilings have this wave notch on the same Lead in 3 cases (Cases 5, 7 and 9) and on almost the same Lead in 5 cases (Cases 1, 4, 10, 12 and 13). One of the twin sibilings has the notch in 1 case (Case 11). Neither of the twins have the notch in 3 cases (Cases 2, 3 and 6). In general, the abnormal left deviation of the QRS axis is seen in such cases as anterior left bundle branch block, anterior wall infarction with anterior left bundle branch block, left ventricular hypertrophy with anterior left bundle branch block, chronic coronary artery disease with anterior left bundle branch block, pseudo-left-axis deviation due to chronic diffuse lung

disease, diffuse myokardose, inferior wall infarction, inferior wall infarction with anterior left bundle branch block, hyperkalemia, acute cor pulmonale and some congenital heart diseases (endocardial cushion defects, common A-V orifice, tricuspidal stenosis, VSD, coarctation of the aorta and aortic stenosis). In the cases observed in this study, no such sbnormal symptoms or diseases are found. The notch on the QRS wave is often observed in the left axis deviated cases, but sometimes seen in cases whose axes are not deviated to the left (Cases 1, 4 and 9).

In the dizygotic twins, both of the twin sibilings have the QRS wave notch in 2 cases (Cases 2 and 4) and one of the twins shows the QRS wave notch in 2 cases (Cases 1 and 5). In control group, the wave notch is seen only in 3 cases out of 34. These 3 cases with the wave notch are not clinically abnormal with no subjective and objective sysmptoms, but from the electrocardiographycal point of view, the wave notch is mainly observed in cases of the combination of Lead I and aV_L or Lead III and aV_F. The former hints slight electric conduction disturbance in the left bundle branch region and the latter in the lower wall conduction system.

Findings of heart and lung X-ray films

In the monozygotic twin group, sibilings are alike each other in the outer figure of heart and in the heart/lung ratio in all cases and their heart/lung ratios are all within normal limits, and in almost all cases the arterioscrelotic figure of the clear shadow of the aortic arch and the descending thoracic and abdominal aorta is evident in the X-ray films. Inthe dizygo tic twin group, the heart/lung ratio is within normal limits in all cases, but the outer shape of heart is different in all pairs of twin sibilings and no arteriosclerotic figure is found except in Case 4. These findings suggest that in monozygotic twins the arteriosclerosis should have a tendency to increase as they grow older.

There are some reports on the findings of electrocardiograms of twins. Mathers et al[6]. examine the intervals and heart rate of electrocardiograms and the blood pressure of 34 pairs of monozygotic twins who are more than 18 years old and consisting of male twins at the average of 25.4 and female twins at the average age of 29.5, compare those findings with those of 19 pairs of dizygotic twins, and report the genetic effects on the blood pressure and such intervals as PQ, QRS and ST, but not on the QRS axis. Perez, et al[9]. study the eletrocardiogram of 75 pairs of monozygotic twins and of their families, compare those findings with those between twin sibilings or between twins and either of their parents or non-twin sibilings, and use such criteria as 1) variations greater than 10° in the frontal plane axis, 2) variations greater than 20% in such inturvals as P duration, P-R interval, duration of the QRS complex and Q-T interval, 3) variations greater than 20% in the amplitude of the various waves (P, QRS and T), 4) variations greater than 20% in heart rate, 5) changes in polarity (perticularly in those of ST segment and of T wave), 6) presence or absence or rhythm disturbence, and 7) overall impression of a particular tracing whether it is normal or abnormal, in order to judge the similarity or difference in the findings of electrocardiograms of mono- and dizygotic twins. Simonson[11] makes a report on the variation of QRS axis mean in many non-twin control cases. According to his report, the QRS axis mean is $62.9 \pm 26.9°$ in males aged 20-29 in 115 cases, $51.7 \pm 29.1°$ aged 30-39 in 110 cases, $37.2 \pm 32.0°$ aged 40-59 in 424 cases and $61.2 \pm 21.9°$ in females aged 20-29 in 104 cases, $53.8 \pm 24.8°$ aged 30-39 in 65 cases, $41.9 \pm 25.8°$ aged 40-59 in 142 cases respectively. These findings show that the QRS axis mean has a tendency to more deviate to the left in males than in females with the increase of age. Wise et al[14]. reports the relation between the QRS axis mean and the body weight. He points out that some cases of heavy body weight and high position of diaphragma have a tendency to deviate to the left. But we find in some cases of monozygotic twins not only the heavier by 5-10 kg (Cases 2, 7 and 9) but also the lighter by 10 kg (Cases 11 and 12) than the other show a tendency to deviate to the left respectively. In the dizygotic twins, the heavier ones show the left axis deviation (Cases 3, 4 and 5). As for the height, monozygotic twins are about the same in all cases except in Case 11, where the shorter one by about 20 cm shows the left axis deviation. As seen in Cases 2, 5, 7, 8, 10 and 12, there is some difference in the QRS axis between twin sibilings of about the same height. The dizigotic twins, though small in number, show little dif-

ference in the axis.

The relation between the atomic bomb exposure and the QRS axis

Tables 1 and 2 show he relation between the atomic bomb exposure and the QRS axes of mono- and dizygotic twins. In Cases 2, 3, 5, 9, 10 and 11, both of the monozygotic twins are exposed to the atomic bomb under almost the same condition. In Cases 6, 7, 8, 12 and 13, one of the twins is exposed and the other is not exposed. In Case 1, neither of the twins are exposed. These Tables contain those who entered Hiroshima City after the atomic bomb explosion for the purpose of checking the late indirect effects of radiation of the atomic bomb. In the dizygotic twin group, one of the twins is exposed is Case 4. In Case 5, each of the twins is exposed under the different conditions respectively. In Cases 1, 2 and 3, neither of the twins are exposed to the atomic bomb. In the monozygotic twins, the relation between these conditions of the atomic bomb exposure and the QRS axis or the wave notch of their electrocardiograms will tell us that those who were exposed to the atomic bomb near the hypocenter (Cases 7-1, 8-2 and 10-2) show a tendency to have a left axis deviation. But this is not always true as we see in Cases 2-2, 3-1, 3-2 and 12-1. In the dizygotic twins, the tendency to the left axis deviation is seen in one of the twins exposed near the hypocenter in Cases 4-2 and 5-1. But the notch on R wave is not observed in Case 5-1. These findings will not be enough to clear up the relation between the atomic bomb exposed and the abnormal eleotrocardiograms. In conclusion, the tendency to the left axis deviation of the monozygotic twins, with the findings of the notch on R wave and arterioscrelosis, suggest that some cases of monozygotic twins should have a tendency to aging. After the lapse of over 30 years since the atomic bombing, it is not easy to investigate its effects. As long as the atomic bomb survivors are alive, however, the work has to be continued. Whether the clinical data prove the relationship to the atomic bomb to be positive or negative, they will be useful for the health managemant of the survivors. We will continue to assumulate such cases as these over a long period of time.

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