Heart Disease Program for School Children and High School Students in Osaka City: An Introduction of Computer Assisted ECG Analysis System as a Screening Tool

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Fukuda ECP-100 computer assisted ECG analysis system was introduced into the heart disease program for school children and high school students in Osaka City in 1979. This analysis system was used as screening tool and 39,532 of 4th graders of primary schools were examined during the first year. To evaluate and improve this analysis system a "pilot study" was organized and 52 school physicians and 10 specialists made up a "working group". "Urgent reference codes" were set to be printed out so that the limitation of the present system of the Heart Disease Program should be compensated.

Problems of the ECG analysis system were as follows. The Q wave registered too wide and there were some difficulties in recognizing the end point of the T wave. Recognition of tiny "r" wave seemed to be impossible and base line sway seemed responsible for numerous erroneous outputs. Some cases corresponding to code "4-n-n" were found to be normal after further examination.

This system can be said to be useful as a screening tool. Using this system at least 4 cases of serious lesion were newly detected, one case of myocarditis and 3 cases of myocardial diseases.

IN 1958 Heart Disease Program for school children and high school students started in Osaka City. In this program first graders of primary school and first graders of high school were to be screened by auscultatory findings, by miniature X-ray findings and questionnaire concerning history and subjective complaints of heart and related diseases. About 3% of the first graders of primary school and 5% of the first graders of junior high school were to be screened positive, then further examination had been

carried out at the Children's Medical Center of Osaka City, at the Center for Adult Diseases, Osaka or at the Anti-tuberculosis Association of Osaka Branch.

In 1973 the regulations of School Health Law was partially amended, and heart check became compulsory as a part of regular physical examination at school. Therefore, since 1974 mass examination for heart disease widespread in Japan. Osaka City was one of the pioneer organization which started Heart Disease Program prior to the above amendment. In 1974 the Anti-tuberculosis Association of Osaka Branch withdrew from the program and the Children's Medical Center of Osaka City was obliged to cover schools which had been covered by the

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TABLE 1 CASES WITH "URGENT REFERENCE CODES"

category and codes	No. of cases	No. of correct	No. of fault	*1	supposed causes			*4
					*2	*3		
1. abnormal Q								
1-1-1	15	0	15	6	9	—	—	
1-2-2	18	0	18	—	18	—	—	
1-2-6	1	0	1	—	—	1	—	
2. 1. + ST depres.								
1-1-1 + 5-2-0	4	0	4	4	—	—	—	
1-2-6 + 5-2-0	1	0	1	1	—	—	—	
3. 1. + others								
1-1-1 + other	3	3	0	—	—	—	—	
1-1-5 + other	1	1	0	—	—	—	—	
1-2-6 + other	1	1	0	—	—	—	—	
4. ST depression								
4-1-0	7	1	6	—	—	—	—	6
5. ST-T abnorm.								
4-1-0 + 5-1-0	1	0	1	—	—	1	—	
4-1-0 + 5-2-0	32	5	27	—	—	4	23	
6. T wave abnorm.								
5-1-0	1	0	1	—	—	1	—	
5-2-0	84	0	84	—	—	52	32	
5-2-0 + other	2	2	0	—	—	—	—	
5-3-0	28	0	28	—	—	27	1	
7. bradycardia and other								
8-8-0	52	0	52	—	52	—	—	
8-8-0 + other	6	2	4	—	4	—	—	
8. QT prolong.								
9-7-0	11	0	11	—	11	—	—	
9-7-0 + other	2	1	0	—	1	—	—	
Total	270	16	254	11	95	86	62	

(43 cases with lead errors and 10 cases with dextrocardia were excluded)

*1: erroneous recognition of shape

*2: faulty calculation of timing

*3: fault calculation of amplitude

*4: base line sway may be responsible for misjudgement

above association. Then the examination system was modified.

In the beginning the Heart Disease Program was started by members of the Department of Public Health, Osaka University Medical School and the main subject was "rheumatic heart disease"^{1,2}. As the program progress rheumatic heart disease decreased and relatively rare diseases such as myocardial diseases were closed up as an important disease.

Since 1974 when the Section of School Physicians was established in Osaka Prefectural Medical Association, the affairs related to the mass control of heart diseases among school children were brought under the activity of Heart Disease Control Committee of this section.

Through the study of the Committee a computer assisted ECG analysis system was introduced into the Heart Disease Program of Osaka City as a screening tool in 1974 to meet the

TABLE II RESULTS OF PILOT STUDY

Computer	Doctor's read			Total
	Normal (1-0-0)	Within normal limits	Abnormal	
Normal (1-0-0)	A. 2,328	D. 10	G. 23	2,361
Within normal limits	B. 104	E. 342	H. 2	448
Abnormal	C. 29	F. 14	I. 145	188
Total	2,461	366	170	2,997

(26 schools and 3,165 children)

Four cases with leads error, 39 cases absented, 123 cases with analysis cancel and 2 other cases were excluded.

changing epidemiological feature of heart diseases among children.

METHODS AND MATERIALS

This new method was applied only for the 4th graders of primary schools. The amount of the budget prepared by the Education Board of Osaka City was 30 million yens for the first year.

The number of the 4th graders examined by this method was 39,532. Before further examination at the Children's Medical Center of Osaka City, the children screened positive were examined by again ECG and PCG recorded by the Osaka Branch of Preventive Medical Association, so that the numbers of the children for further examination met the capacity of the Children's Medical Center of Osaka City. The second step ECG and PCG records were read by school physicians with pediatric cardiologists belong to "working group" of the Heart Disease Program.

The analysis system was Fukuda ECP-100 with Camps-5 Version 4. Although screening with computer assisted ECG analysis system was scheduled to be done in the first school term, the second step could not been done during the first school term, "urgent" reference codes" were set so that the further examination should not be delayed for the cases suggesting myocardial diseases or dangerous arrhythmias.

The "urgent reference codes" are as follows:

- 1-1-1 $Q/R \geq 1/3$ & $Q \geq 0.03$ sec in I or V_6
- 1-1-2 $Q \geq 0.04$ sec in I or V_1 or V_6
- 1-2-2 $0.03 \text{ sec} \leq Q \leq 0.04 \text{ sec}$ in I or V_6
- 1-2-6 $-Q \geq -0.5$ mV in I or V_6
- 1-3-6 QS pattern in aVF
- 4-1-0 $-ST-J \geq -0.1$ mV & ST-seg•flat, depres. in I or V_6
- 4-2-0 $-0.05 < -ST-J \text{ depres.} < -0.1$ mV & ST-seg•flat, depres. in I or V_6

- 5-1-0 Neg T ≥ -0.5 mV in I or V_6
- 5-2-0 Neg. T(+, -) & $-0.1 \leq \text{Neg. T} \leq -0.5$ mV in I or V_6
- 5-3-0 T = or Neg. T or T (-) & $T < -0.1$ mV in I or V_6
- 6-4-0 $PQ < 0.1$ sec & $QRS \geq 0.1$ sec & VAT ≥ 0.04 sec in I
- 6-4-0 $PQ < 0.1$ sec & $QRS \geq 0.1$ sec & VAT ≥ 0.05 sec in V_6
- 7-1-0 + 8-8-0: 7-1-0 ($QRS \geq 0.1$ sec & VAT ≥ 0.05 sec & absent Q in or V_6) and 8-8-0 (HR 55)
- 7-2-0 + 8-8-0: 7-2-0 ($QRS \geq 0.1$ sec & $R_1 < R_2$ or VAT ≥ 0.05 sec in V_1)
- 7-4-0 + 8-8-0: 7-4-0 ($QRS \geq 0.1$ sec in V_1)
- 9-7-0 QT Table (under the Korth QT table).

For evaluation and improvement of this system, one tenth of the schools, one or two schools from each of the 26 wards of Osaka City, were selected and studied as a "pilot study". To perform the actual work, 52 school physicians and 10 specialists were organized into a "working group".

RESULTS AND COMMENTS

Table I shows the results of double check by "working group" and Computer read. Among 39,532 children 323 cases were labeled "urgent reference". However, actually 16 cases were considered to be really compatible with "urgent reference code". The probable reasons of erroneous computer diagnoses were shown in the Table. Concerning the erroneous Q wave reads, it was considered that the computer had tendency to read timing wider, concerning ST-T changes sway of baseline seemed to be responsible. Concerning QT prolongation computer seemed unable to recognize the end point of T wave which returns slowly to the base line.

TABLE III SENSITIVITY, SPECIFICITY AND EFFICIENCY OF ABNORMAL CODES

Category	QRS axis anomaly	long PQ	RVH	LVH	intra-vent. conduction disturb.	tachycardia	bradycardia	WPW	ST change	Q wave abnorm.
Codes	2-1-0	6-3-0	1-3-7	3-1-0	7-3-0	8-7-0	8-8-0	6-4-0	4-1-0	1-1-1
	2-2-0		3-2-0	3-3-0	7-5-0 + 2-1			7-1-0	4-2-0	1-2-2
	2-4-0		5-5-0	5-2-0	7-2-0				4-3-0	1-2-6
				5-3-0	7-4-0					
No. of cases with computer (+) doctor (-)	4	0	19	21	11	2	4	0	6	1
No. of cases with computer (+) doctor (-)	41	0	10	23	64	1	10	1	1	0
No. of cases with Computer (+) doctor (+)	0	2	0	0	21	0	2	1	3	0
Sensitivity	1	0	1	1	0.753	1	0.833	0.500	0.250	—
Specificity	0.999	—	0.994	0.993	0.996	0.999	0.999	0.999	0.998	—
Efficiency	0.999	0	0.994	0.993	0.750	0.999	0.832	0.499	0.245	—

Table II shows the results of double check of ECG interpretation in the "pilot study". The number of the children included in "pilot study" was 3,165, however, actually 2997 cases were available for study, because 39 were absent and 129 cases were unsuccessful in obtaining ECG record by computer assisted apparatus.

Twenty-three cases of normal computer output were considered to be abnormal by "working group" doctors (category G in the Table). These 23 cases included one case of ST depression in V_6 (4-1-0), 2 cases of ST depression in V_6 (4-2-0), 14 cases of incomplete right bundle branch block (7-3-0), 5 cases of arrhythmia (8-9-0) and one case of PQ prolongation (6-3-0). Two cases belong to category H were the cases with (7-5-0) code which were considered to be rather (7-3-0) by "working group" doctors. The discrepancy in codes (7-3-0) or (7-5-0) was considered to be due to that CAMPS-5 lacked the code corresponding to the finding " $R_1 < R_2$ and $R_2 > 0.2$ mV & $R_2 \times 1.5 < S$ " between "7-3-0 ($R_1 < R_2$ & $R_2 \times 1.5 > S$ in V_1)" and "7-5-0 ($R_1 > R_2$ in V_1)".

Table III shows the specificity, sensitivity and efficiency of codes which correspond to abnormal findings. The indices were poor especially for codes "7-n-n" and "4-n-n".

Although these were not tabulated, the specificity, sensitivity and efficiency of each categorized group which falls in within normal limits are as follows: indices of Q wave anomaly (1-2-1, 1-3-1, 1-3-2) are 0.987, 0.990 and 0.977 respectively; indices of QRS axis anomaly (2-3-0) were 1, 0.999 and 0.999 respectively; indices of incomplete right bundle branch block (7-5-0) were 0.912, 0.998 and 0.910 respectively; indices of low voltage (9-1-0) were 1, 0.999 and 0.999 respectively; indices of ST elevation (9-2-0) were 1, 0.974 and 0.974 respectively; indices of suspected right atrial enlargement (9-3-1) were 1, 0.999 and 0.999 respectively; indices of suspected left atrial enlargement (9-3-2) were 1, 0.984 and 0.984 respectively and indices of T wave anomaly (9-5-0) were 1, 0.999 and 0.999 respectively. Computer reading seemed reasonably to this extent.

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