Pulmonary Circulation

—Electrocardiographic Study on Right Ventricular Hypertrophy Especially in Patients with Chronic Obstructive Pulmonary Disease—

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DISTURBED pulmonary circulation in chronic pulmonary disease causes right heart overloading frequently. The objectives of this study is to investigate diagnostic significance of electro-

cardiographic findings, especially of P wave axis deviation, as an index of pulmonary circulatory disturbance in chronic obstructive pulmonary disease. Value of intraventricular electrocardio-

TABLE I POSITIVE RATE OF THE ECG FINDINGS IN THE TWO GROUPS
SEGREGATED FROM PROGNOSTIC VIEW POINT

Key Words:
Right ventricular hypertrophy
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Fig.1. Relationship between pulmonary arterial mean pressure (PAm) and P wave axis in the frontal plane.

○ : case died of cor pulmonale

K.N 55 male 1965-6-6

Fig.2. ECG of a 55-year-old male with chronic pulmonary emphysema. P wave in the frontal plane is $+115^\circ$ and QRS axis is also $+115^\circ$. Note negative P in lead I. Precordial leads show no sign for right ventricular hypertrophy. PAm = 33mmHg, PVRI = 662 dynes $\cdot$ $\text{cm}^{-5}/\text{M}^2$.

Fig.3. Relationship between pulmonary artery mean pressure (PAm) and the A ratio in right ventricular outflow tract or mid ventricular cavity.

graphy in diagnosis of right heart overloading was also investigated.

SUBJECTS AND METHODS

Electrocardiograms obtained from two groups of patients with chronic obstructive pulmonary disease, especially pulmonary emphysema, were analysed; one group was those who died of chronic cor pulmonale complication during this study period, another group was those who were still alive at the time of the study and those who died of other causes than cor pulmonale. Total number of subjects was 102. Of all subjects, cardiopulmonary hemodynamic studies by right heart catheterization had been performed prior to this study.

Electrocardiographic findings of these subjects were studied to compare with pulmonary hemodynamics. P wave axis was determined by P wave heights on lead I and III of electrocardiogram (ECG), following Einthoven's procedure¹.

Of 15 patients, intraventricular ECG was obtained following the procedure reported previously². This is a bipolar ECG recorded

Fig.4. A case of intraventricular ECG of a 64-year-old male with chronic pulmonary emphysema. PAm of this patient was 20mmHg and the A ratio was 1.12.

RV: right ventricular pressure curve in outflow tract

PA: pulmonary artery pressure curve

IV-ECG: intraventricular electrocardiogram

ECG: electrocardiogram in lead II.

between right ventricle (inflow tract, outflow tract, and midpoint) and anterior chest wall (6 spots). Right ventricular vector component (A_R) and left ventricular component (A_L) were calculated and expressed in terms of the A ratio (A_R/A_L) to compare with pulmonary hemodynamics.

RESULTS

1) In comparison of the two groups segregated from prognostic view point as described above, the most prevalent ECG abnormality among 21 patients died of cor pulmonale was right axis deviation of P wave.³ Incidence of right axis deviation of P wave more than $+80^\circ$ on the frontal plane was 81% in this group. The incidence of this sign in the patients who were still alive or those who died of the causes other than cor pulmonale was 36% (Tab. I). Incidences of all other ECG findings were low and not segregative as shown in Table 1. The prominent difference in incidence rate of right axis deviation of P wave seems strongly suggestive of that the sign may reflect right heart overloading or pulmonary circulatory disturbance most adequately. P axis in the frontal plane correlated with pulmonary artery mean pressure (PAm) as shown in Fig. 1 ($r + 0.60$, $P < 0.01$); all the patients whose P axis was more than $+80^\circ$ showed pulmonary hypertension of PAm over 17 mmHg except 4 cases. In Fig. 1, ECG of an illustrative case is shown. Frontal plane P axis was $+115^\circ$, and PAm was 33 mmHg. At autopsy, marked right ventricular hypertrophy was observed.

The P axis seemed to correlate with pulmonary vascular resistance but not with cardiac output or right ventricular pressure.

2) The A ratio of all patients with pulmonary hypertension of PAm over 17 mmHg was larger than 0.9 except a case, while in patients with PAm below 16 mmHg the ratio was smaller than 0.9 (Fig. 3). This relationship between the A ratio and PAm was positive when the intraventricular electrode was placed in outflow tract or mid ventricular cavity, but was not positive when the electrode was placed in inflow tract. In Fig. 4 another illustrative case of chronic pulmonary emphysema is presented. PAm of this patient was 20 mmHg and the A ratio was 1.12. Standard 12 lead ECG revealed deep S in V_5 , notched S in V_1 , and frontal plane P axis was $+85^\circ$.

DISCUSSION

Abnormal P wave in chronic pulmonary disease has been recognized as "pulmonary P" since Winternitz had described it in 1935. However, incidence rate of the pulmonary P was low in our series of patients even in the patient group died of cor pulmonale (24%). Furthermore, occurrence of the pulmonary P was not reproducible frequently.

Right axis deviation of P wave seemed more reliable to evaluate the disturbance. First of all, the deviation towards right become more evident as pulmonary circulatory disturbance progressed. Mechanism involved in development of right axis deviation of P wave remains to be investigated further. However, it seems highly possible that the deviation reflects more adequately right heart overloading or pulmonary circulatory disturbance because P wave axis correlates well with pulmonary artery pressure and pulmonary vascular resistance. Position and rotation of the heart may be the contributing factors to be taken into counts from anatomic-pathological view point because right axis deviation of P wave occurs frequently in chronic pulmonary emphysema.

The A ratio seemed to be an useful mean for early diagnosis of right heart overloading as evidenced by our study. Pulmonary hypertension was detected in 7 of 15 patients on whom intraventricular ECG had been worked. Five of this 7 hypertensive patients had not the signs and symptoms to meet the diagnostic ECG criteria of right ventricular hypertrophy proposed by Roman *et al.*⁴ or set by WHO committee.⁵ Contrary the A ratio of these 5 patient was larger than 0.9 segregating clearly pulmonary hypertensive patient from normotensive patients.

CONCLUSION

With comparative investigation of pulmonary hemodynamics and ECGs in patients with pulmonary hypertension, it was concluded, tentatively at least, that right axis deviation of P wave in the frontal plane and the A ratio calculated on the basis of bipolar intraventricular ECG were more reliable and accurate clinical index than other previous indices in diagnosing pulmonary hypertension and right heart overloading.

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