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APEXCARDIOGRAPHIC INDEX "C-⊿ACG" II. CLINICAL STUDIES

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Abstract

Clinical study was conducted on apexcardiographic index "C-⊿ACG" and the following results were obtained.

1. The value of this parameter in normal subjects was 57.0 msec ± 12.0, and it seemed not to be affected by heart rate.

2. As this parameter was affected by the posture, it may be necessary to make a recording at a constant posture.

3. The mean values of this parameter in heart disease groups were significantly prolonged as compared with normal group. On the other hand, in hyperthyroidism group it was significantly shortened. Further, it was prolonged as the severity of cardiac functional classes advanced.

It is concluded that this parameter can serve as one of the simple, useful and noninvasive method for the evaluation of cardiac status and the severity of cardiac disease to a certain extent.

INTRODUCTION

Recently the first derivative of the apexcardiogram (⊿ACG) has been used for evaluating the left ventricular function.[1-11] The author likewise studied "C-⊿ACG", the time interval from the C point of the apexcardiogram (ACG) to the peak of ⊿ACG, in animal experiment, and reported that this parameter would be useful for evaluating the cardiac contractility.[12]

In this paper, a clinical usefulness of "C-⊿ACG" was studied.

SUBJECTS AND METHODS

A total of 121 subjects was selected and they were subdivided into 6 groups as seen in Table 1. Patients with hypertension were eliminated from the study.

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Table 1. Classifications of total subjects

Diagnosis	No. of cases	Age (mean)	Sex : male	female
1. Normal volunteer	40	21~60 y. o. (34 y. o.)	31	9
2. Ischemic heart disease (IHD)	43	33~73(54)	30	13
Old myocardial infarct	25			
Angina pectoris	12			
IHD without symptom	6			
3. Congestive cardiomyopathy (CCM)	9	20~52(38)	7	2
4. Valvular heart disease (VHD)	13	25~70(46)	8	5
Mitral regurgitation (MR)	7			
MR + mitral stenosis	6			
5. Congenital heart disease (CHD)	6	26~46(34)	4	2
Ventricular septal defect	4			
Endocardial cushion defect	2			
6. Hyperthyroidism	10	22~47(37)	2	8
Total	121		82	39

After 15-minute bed rest, both ACG and ΔACG were simultaneously recorded at a paper speed of 100 mm/sec in mid-expiratory apnea with patients in left lateral position at the level about 60°. The drugs affecting cardiac function were all discontinued 24 hours before the study (to be mentioned later).

A transducer (TY 303, Fukuda Electronic Co.) for ACG and RC circuit with time constant of 1 msec for ΔACG were used. Fig. 1 shows the measurement of "C-ΔACG" ("C-ΔACG" is the time interval from the C point of ACG to the peak of ΔACG). These measurements were made by the average value of 3 consecutive tracings.

RESULTS

1. The normal value

The value of "C-ΔACG" was 57.0 msec $\pm$ 12.0 (mean $\pm$ 2SD) in 40 healthy persons.

2. Effect of heart rate on "C-ΔACG"

Fig. 2 shows the relationships between heart rate and "C-ΔACG" in 40 healthy persons. No significant influence of heart rate on "C-ΔACG" was found. By increasing heart rate up to 120/min by right atrial pacing in six patients, the effects of heart rate changes on "C-ΔACG" was studied (Fig. 3). No significant changes resulted in "C-ΔACG" by increase of heart rate.

3. Effect of posture at the time of recording.

For the purpose to study the effect of the posture on "C-ΔACG", 20 patients were selected, and tracings were made in various postures such as in

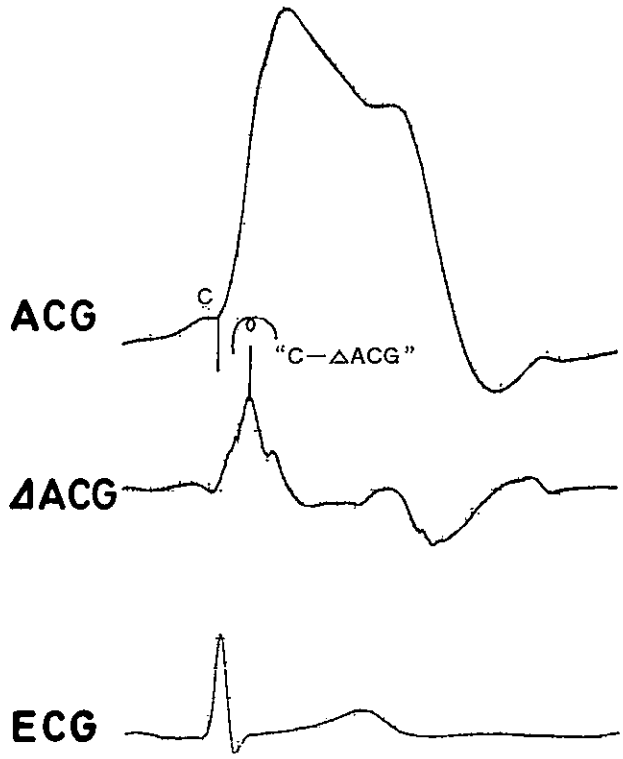

Fig. 1. Measurement of "C-⊿ACG" with apexcardiogram (ACG) and its first derivative (⊿ACG).
"C-⊿ACG" is the time interval from the C point on ACG to the peak of ⊿ACG.

supine and in left lateral position at the angles of 30°, 45°, 60°, and 80°. Fig. 4 shows the "C-⊿ACG" values at various postures expressed by percentage(%) change with standard position (60°-left lateral position) as 0 %. The values was the longest in supine position, and more the angle in the left lateral position increased, more its value was shortened. At 80° the "C-⊿ACG" value was shortened, and at 45° it was lengthened, but in either position there were no significant differences as compared with the standard position. However, at 30° and in supine position this value was lengthened significantly ($p < 0.01$).

4. Reproducibility of the value (Fig. 5)

With 15 normal volunteers the reproducibility of "C-⊿ACG" was assessed at intervals of 4 to 7 days.

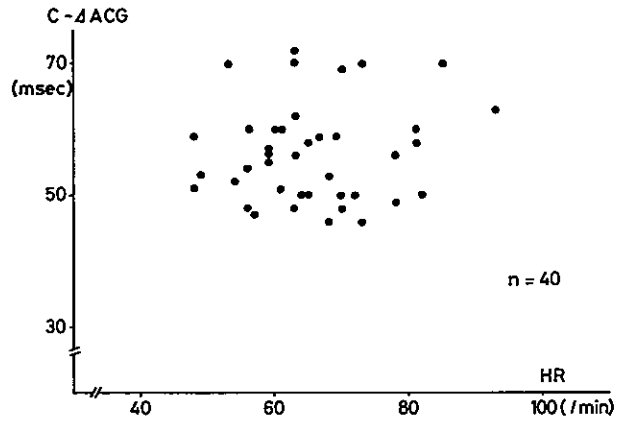

Fig. 2. Relationship between heart rate and "C-ΔACG" in normal volunteers.

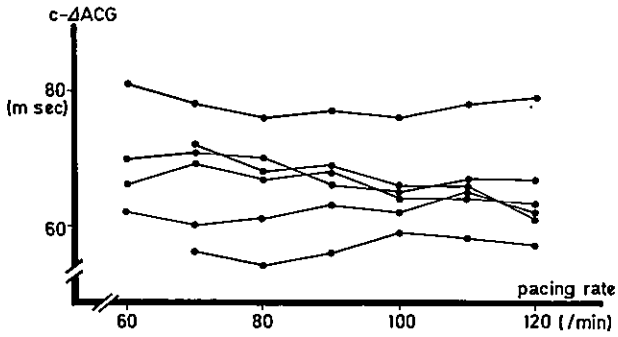

Fig. 3. The changes in "C-ΔACG" following the right atrial pacing in six cases.

The correlated values between the first and second recordings indicated a highly positive correlations ($r = +0.90$).

5. The value in various heart disease (Fig. 6)

The mean "C-ΔACG" value in ischemic heart disease (IHD) group was 63.3 msec $\pm$ 2.73 (mean $\pm$ 95 % confidence limits) and in congestive cardiomyopathy (CCM) group it was 75.2 msec $\pm$ 9.66. Both values were significantly prolonged ($p < 0.05$ in IHD group, $p < 0.01$ in CCM group) when compared with normal group (57.0 msec $\pm$ 2.30). In addition, in valvular heart disease (VHD) and congenital heart disease (CHD) groups it was 62.8 msec $\pm$ 3.77, also showing a significant prolongation ($p < 0.05$).

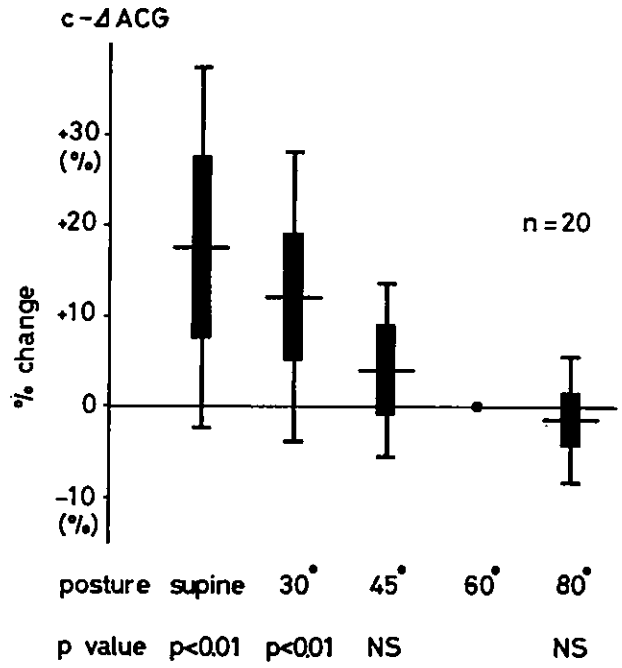

Fig. 4. Changes of "C-⊿ACG" in various postures.
Bars indicate mean value ± 1 standard deviation.
Thick columns indicate ± 95 % confidence limit.
P values: between 60° and other posture.

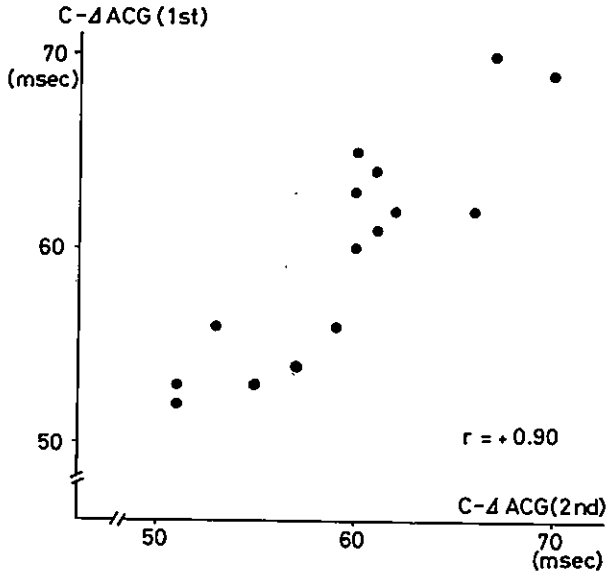

Fig. 5. Reproducibility of "C-⊿ACG"

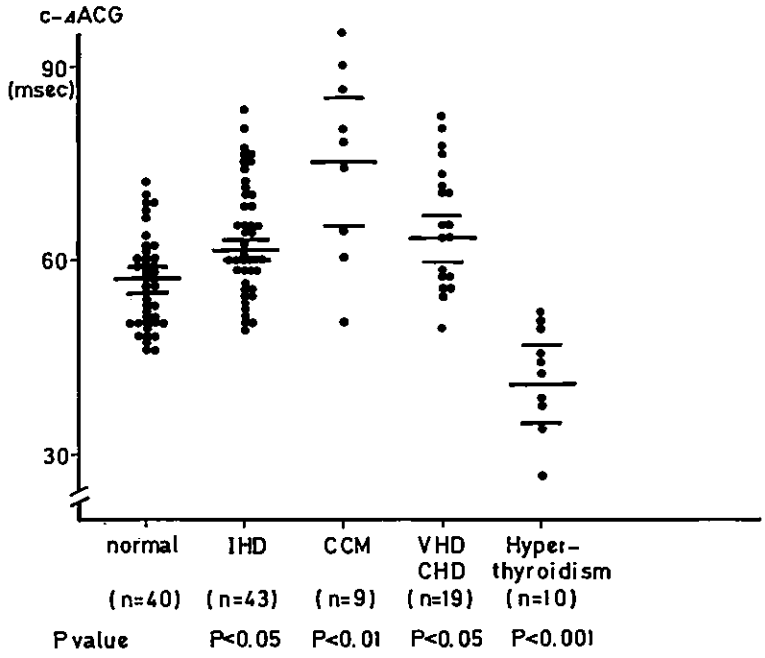

Fig. 6. "C-⊿ACG" in various heart disease
Bars indicate mean value ± 95% confidence limit
IHD: ischemic heart disease
MD: myocardial disease (congestive type)
CHD: congenital heart disease
VHD: valvular heart disease
P value: between normal group and each heart disease group

On the contrary, in hyperthyroidism group it was 40.8 msec ± 5.70, being significantly shortened ($p < 0.001$).

6. The value in various cardiac functional states (Fig. 7)

These patients with cardiac disease, excluding hyperthyroidism, were classified into I°, II°, III°, IV° by New York Heart Association (NYHA) criteria according to their severity of the cardiac functional capacity.

The mean "C-⊿ACG" was 66.0 msec ± 3.39 in NYHA II° group and 73.6 msec ± 5.40 in NYHA III° group, both of which were significantly prolonged ($p < 0.001$ in NYHA II°, $p < 0.001$ in NYHA III°) when compared with normal group.

All four cases of NYHA IV° group showed a marked prolongation of "C-⊿ACG" (mean value of 83.0 msec). No significant differences, however, observed between NYHA I° group and normal group.

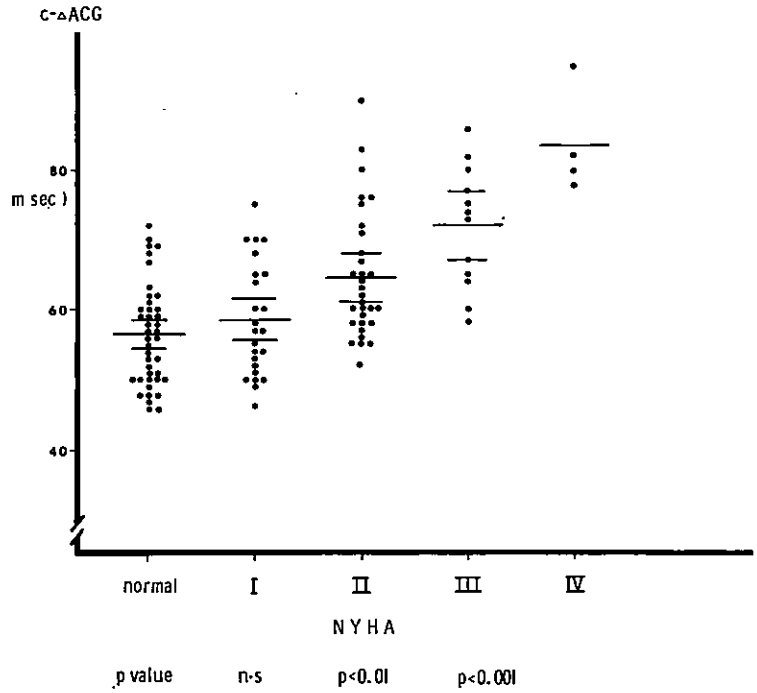

Fig. 7. " C-⊿ACG " in various cardiac functional classes (NYHA) classification
P value: between normal group and each cardiac class group

DISCUSSION

Although the exact genesis of the ACG is still not clearly understood, a close correlation has been shown to exist between the ACG and the hemodynamic events in the left ventricle[3,13–16]. Particularly, a marked synchroism between the upstroke of the ACG and of the left ventricular pressure curve has been demonstrated.[13,15] Based on these considerations, the first derivative of the ACG (⊿ACG) has been used for assessment of the left ventricular function.

In the previous report[12] the author demonstrated that the change of " C-⊿ACG " proved a good correlation with that of invasively derived parameters closely related to contractility, and that this parameters seems to be particularly useful for the detecting changes in the left ventricular contractility within the same individual.

The mean values of " C-⊿ACG " in all three groups with heart disease were significantly prolonged as compared with normal group (Fig. 6). It is

suggested that the left ventricular contractility is decreased in many cases of these heart disease group.

On the other hand, " C–ΔACG " in hyperthyroidism was significantly shortened. In this disease, the contractility is accelerated, the results being in agreement with previous reports.[22,23]

Further, as shown in Fig. 7, this parameter was prolonged as the severity of cardiac functional classes advanced.

In the experimental study,[12] it was demonstrated that the change of " C–ΔACG " correlated well with that of contractility within the same individual.

From the results of the present study, furthermore, it is suggested that " C–ΔACG " may be useful for differentiating the normal group from the groups of various cardiac disease and be also valuable in estimating the severity of cardiac disease.

As reported[17–19] that the wave form of ACG varies according to the posture at the time of recording, whether or not " C–ΔACG " would be changed by various postures at the time of recording was studied. As shown in Fig. 4, this parameter varied by the posture, i. e. it was prolonged as the angle of the left lateral decubitus position was decreased. Although the reason being obscure, one of the possible explanations may be due to the fact that the coupling of the thoracic wall with the heart can be changed by the body position. It is, therefore, necessary to keep the posture of the subject approximately constant at the recording of ACG.

It is reported[20,21] that " t–ΔACG " showed no significant correlation with any of the internally measured indexes of myocardial function. Such contention may be in part arisen from the posture at the recording.

The reproducibility of " C–ΔACG " was fairly good as seen in Fig. 5.

ADVANTAGE OF THIS METHOD

Adequate parameter for measurement of contractility derived from non-invasive approach is lacking. Isometric contraction time (ICT), the interval obtained by subtracting the ejection time from S_1–S_2 interval (from the beginning of the 1st to the 2nd heart sound), often hard to calculate due to the fact that recognition of mitral closure sound (S_1) is difficult to clearly deliniate " C–ΔACG ", on the other hand, is more easy to calculate and no additional tracing other than ACG is needed.

Specific devices (waterfilled chamber, computer etc.) and complicated calibration are necessary for the previously reported methods on ΔACG.[3–10] In contrast, " C–ΔACG " is measured without these specific devices or calibration so that this measurement is considered to more simple method than the previously reported ones.

The " t-ΔACG ", proposed by Reale[1] and Vetter[2], is also simple, but it includes electromechanical interval which differes one subject to another, and is markedly prolonged in left bundle branch block. The present index " C-ΔACG ", is the interval by subtracting electromechanical interval from " t-ΔACG " so that " C-ΔACG " is more theoretical to represent the left ventricular contractility than " t-ΔACG ".

LIMITATION OF THIS METHOD

ACG may not be recorded in some patients such as with obesity or pulmonary emphysema. Furthermore, even if the recording can be taken, C point or peak of ΔACG may not be sharply recognizable in some instance.

In addition, as already reported,[12] " C-ΔACG " seems to be affected by afterload so that this parameter should be used in patients with hypertension with careful consideration.

Acknowledgment

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