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AN EVALUATION OF HEMODYNAMIC CHANGES IN CONVERSION OF ATRIAL FIBRILLATION USING LEFT VENTRICULAR SYSTOLIC TIME INTERVALS DERIVED FROM POLYGRAPHIC TRACINGS

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Abstract

The hemodynamic alterations before and after transient atrial fibrillation was observed 20 times in 18 cases by means of the non-invasively derived left ventricular systolic time intervals. The findings of the present study are briefy summarized as follows.

1) After conversion to normal sinus rhythm both the total systole (Q-II) and the ejection time (ET) were prolonged, the pre-ejection period (Q-U) did not change significantly, and the ET/Q-U ratio was increased.

2) In the follow-up observations after the conversion, the ET as well as the Q-II was gradually increased. In contrast, the Q-U was decreased, so that the ET/Q-U was also increased. These changes postulate that the left ventricular function is normalized because of improvement of the booster action of the atrium due to conversion to normal sinus rhythm, supporting the results by the invasive method found in the literature.

INTRODUCTION

The left ventricular systolic time intervals (LVSTI), which have been widely used for the non-invasive assessment of cardiac function, is believed to be most useful especially for analysis of the hemodynamic alterations during arrhythmia in the same individuals. The present investigation was conducted to observe hemodynamic changes before and after conversion to sinus rhythm in cases of atrial fibrillation (Af) using LVSTI.

SUBJECTS AND METHODS

The subjects of our study consisted of 14 males and 6 females with atrial fibrillation that developed in less than one month prior to a visit at our Division of Cardiology. There were 6 cases of ischemic heart disease (IHD), 2 of hyperthyroidism, 2 of mitral stenosis (MS), 2 of mitral regurgitation (MR), 2 of myocardial disease (MD), 1 of congenital heart disease (CHD) and 5 of normal cardiac conditions (so-called lone Af (Table 1).

TABLE 1.

Sex, age, etiology, methods of defibrillation, and follow-up period after conversion of all subjects.

Case	Sex	Age	Etiology	How to convert	Follow-up after conversion
1	M	43	Unknown	Procainamide	2 days
2	M	47	Unknown	Digitalis	3 days
2	M	47	Unknown	DC shock	immed., 1 day, 1 week
4	M	61	MS	Digitalis	2 weeks
5	M	75	IHD	Digitalis	1 week
6	F	54	MD	No Tx	2 days
7	M	54	CHD	Digitalis	immed.
7	M	54	CHD	Qunidine	3 weeks
9	M	73	Myocarditis	No Tx	1 month
10	M	57	Hyperthyroidism	Procainamide	1 month
11	F	55	IHD	DC shock	immed., 1 day, 1 week
12	M	55	Hyperthyroidism	DC shock	immed., 1 week
13	F	69	MS	Digitalis	1 day
14	M	47	Unknown	Procainamide	immed.. 1 day, 1 week
15	M	72	IHD	Procainamide	immed., 4 hours 1 day
16	F	69	MR	Digitalis	immed., 1 day, 1 week
17	F	70	IHD	No Tx	5 days
18	M	62	IHD	No Tx	immed., 1 day, 1 week
19	M	63	IHD	No Tx	immed., 1 week
20	F	45	Unknown	DC shock	immed., 1 day, week
21	M	62	MR	Procainamide }	failed to be
22	M	66	Unknown	DC shock }	converted

In these 20 cases, paroxysmal atrial fibrillations developed 22 times. Medical defibrillation using digitalis (0.4 or 0.8 mg of lanatocide C, intravenously), procainamide (500 or 1,000 mg, intravenously and qinidine sulfate (0.6 mg/day, orally), and electrical defibrillation (DC shock) under intravenous anesthesia by Epontol were given in each occasion. Carotid

arterial pulse (CPA), phonocardiogram (PCG) and electrocardigram (ECG) were simultaneously recorded before and after the defibrillation.

From these tracings the LVSTI were derived as follows: the total systole (Q-II), the ejection time (ET), the pre-ejection time (Q-U) and the ET/Q-U ratio (Fig. 1).

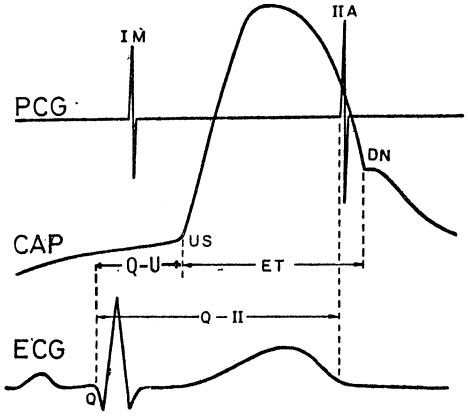

Fig. 1. Measurements of the left ventricular systolic time intervals (LVSTI). PCG; phonocardiogram, CAP; carotid artery pulse, Q-II; electromechanical systole, from the beginning of Q wave on ECG to the aortic component of the second heart sound on PCG, ET; ejection time, from the upstroke to the dicrotic notch on CAP, Q-U; pre-eiection time, from the Q on ECG to upstroke on CAP.

In 20 observations (18 cases) converted to normal sinus rhythm spontaneously (no Tx) or after medical or electrical defibrillation, the following items were evaluated; (1) a comparison of the LVSTI was made in atrial fibrillation and in normal sinus rhythm, and (2) with 9 cases, for follow-up changes in the LVSTI were pursued immediately (immed.), one day and one week after normal sinus rhythm.

In addition, a comparison of the LVSTI in atrial fibrillation and in normal sinus rhythm was made by plotting the values of each parameter against the preceding heart rate (HR). In this instance, since the preceding cycle was irregular in atrial fibrillation, 20 to 30 consective heart beats were taken, and 5 consective beats were averaged in normal sinus rhythm. After conversion to sinus rhythm, a comparison of the LVSTI was made using Q-II index (Q-IIi), ET index (ETi) and Q-U index (Q-Ui) to eliminate the effect of the preceding cycles. Each of these indices was calculated by the following formula obtained by our own normal group of subjects[1].

$$Q\text{-}IIi = -1.70 \times (HR) + (Q\text{-}II)$$
$$ETi = -1.09 \times (HR) + (ET)$$
$$Q\text{-}Ui = -0.88 \times (HR) + (Q\text{-}u)$$

RESULTS

1. The LVSTI before and after conversion to sinus rhythm

Fig. 2 shows the relationship between the LVSTI and HR before

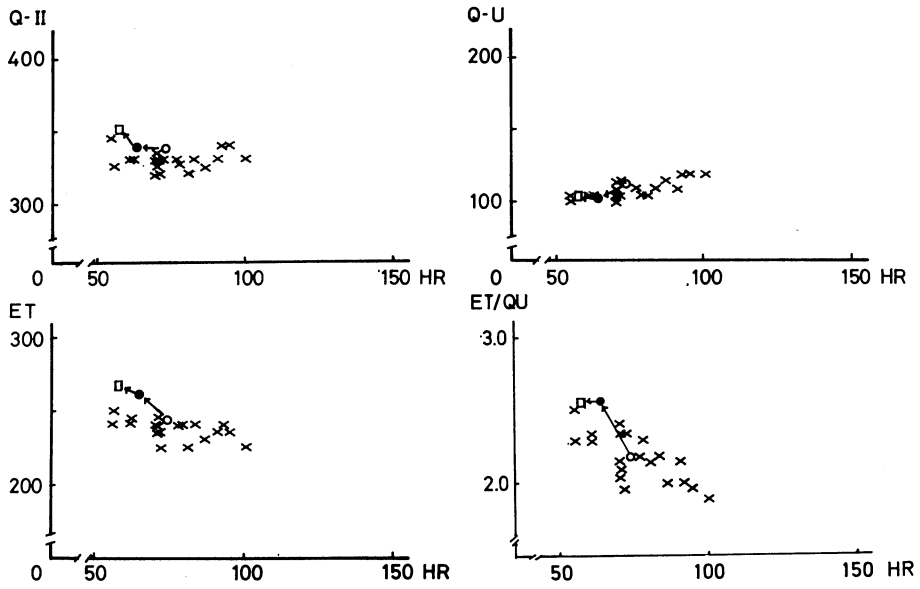

Fig. 2. Effect of conversion from atrial fibrillation to normal sinus rhythm on 4 LVSTI values in case 2 (47 y-o, male). ×; beat-to-beat value before conversion (atrial fibrillation). ∘; value immediately after conversion. •; 1 day after conversion. □; 1 week after conversion.

and after treatment in one patient. On the left upper panel is shown the relationship of Q-II to HR. Compared with the Q-II during atrial fibrillation, that of sinus rhythm was likely to be prolonged at the same preceding cycle. The ET in the sinus rhythm seen on the left lower panel was similarly prolonged, but the Q-U shown on the right upper panel gave no significant differences between the two conditions. In the ET/Q-U ratio the value immediately after the conversion was not significantly different compared to the value during atrial fibrillation, as shown in the lower panel of the figure. In other 19 observations similar findings were obtained.

2. Follow-up observations of the LVSTI after conversion to sinus rhythm

The observations of the LVSTI were carried out on 9 cases immediately and one day as well as one week after the sinus rhythm (Fig. 3).

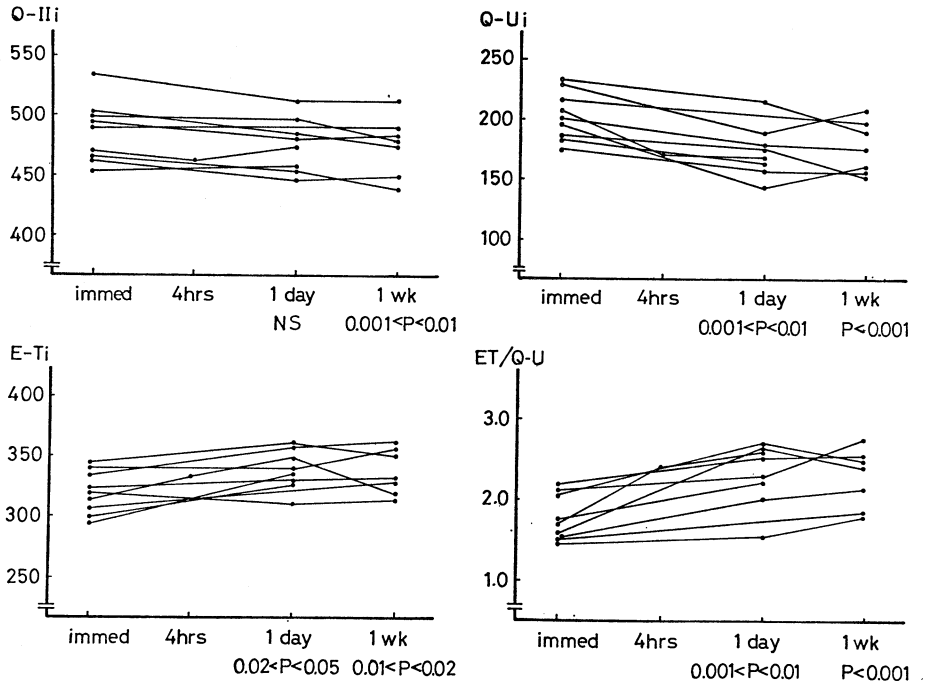

Fig. 3. Follow-up values of LVSTI and the statistical differences (p values) after conversion.

The Q-II, which was prolonged immediately after the sinus rhythm, tended to be decreased one day later, and it was significantly decreased one week later. Similar to the Q-II, the ET was more increased gradually with time course after the conversion. In contrast, the Q-U, which remained unchanged after the conversion, was gradually decreased. Because of increase in the ET and decrease in the Q-U with the time course, the ET/Q-U ratio was gradually increased. Fig. 4 shows the ET/Q-U after the conversion compared with that of atrial fibrillation. Its value, found to low during atrial fibrillation in all cases, fell in the same range immediately after the conversion, but began to be higher gradually.

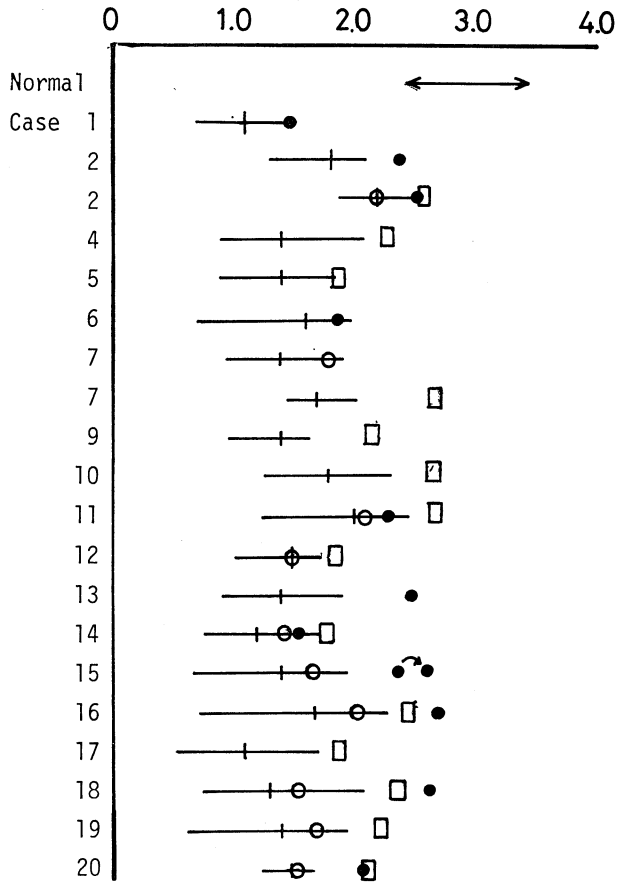

Fig. 4. The ET/Q-U before and after conversion of atrial fibrillation to normal sinus rhythm in 20 patients studied. —|—; range and mean value before conversion (atrial fibrillation), ∘; immediately after conversion to normal sinus rhythm, •; 4 hours to 1 day after conversion, □; more than 5 days after conversion.

DISCUSSION

1. The LVSTI before and after the defibrillation

Along with the defibrillation the LVSTI was altered significantly.

Krohn et al. demonstrated that the ET corrected by Bazett's formula was found to be increased after conversion to sinus rhythm. On the other hand, Tavel et al.[3] observed that in 3 out of 6 cases subjected to defibrillation the ET was more prolonged in sinus rhythm at the same preceding cycles. In our 20 observations the ET after conversion was

greater in every case than that of atrial fibrillation at the same preceding cycle.

The hemodynamic improvement including an increase in cardiac output and stroke volume has been observed by many authors.[4-7] These changes are understood to be due to an increase in stroke volume by an atrial booster action after the conversion even though diastolic filling period may remain unchanged in both rhythms.

The fact that after the defibrillation the Q-U remained generally unchanged and the Q-II became prolonged seems to be due to a prolongation of the ET.

2. Follow-up observations of the LVSTI after the conversion

In the follow-up observations it was found that the ET and the ETi were increased when compared with those during atrial fibrillation, and these values continued to be gradually increased thereafter. The Q-II and the Q-IIi behaved in the similar manner. In contrast, the Q-U immediately after the conversion did not show any appreciable difference from that of atrial fibrillation, but it showed a significant decrease with time course.

Rodman et al.[5] observed that even an atrial activity was recovered by defibrillation, it took a few hours or several days before the full hemodynamic benefit could be restored. Scott et al.[7] demonstrated that the cardiac output did not show any significant change immediately after defibrillation, but three hours later it was increased and three days later it was further increased. These findings suggest that the effective, mechanical atrial activity is improved gradually with time course after defibrillation. The decrease in the Q-Ui mentioned here seems to be due to a gradual increase of a preload following a gradual improvement of the mechanical atrial activity.[8]

As the ET/Q-U (or the ET/PEP) is well known to be a good landmark for the cardiac performance, its slow recovery after the conversion might well be compatible with that as invasively observed by Scott et al.[7]

3. Effects of the drugs used for the defibrillation

Electrical defibrillation may be considered to give an injurious effect on cardiac function.[11] Scott et al.[7] also found no change in the cardiac output by electrical defibrillation. In our present study we used Epontol[12] as the anesthetic for defibrillation. The fact that we could observe an improvement of the LVSTI immediately after the conversion, even if cardiodepressant effects of this drug[13] or procainamide used for

defibrillation are taken into consideration, would suggest that such defibrillation effect on the hemodynamics seems to be significantly beneficial.

Although the Q-U interval used as one of the parameters in the present study is generally measured longer than the PEP (calculated from the difference between the Q-II and the ET) by an interval from the aortic component of the second heart sound to the dicrotic notch of the carotid artery pulse, it would be simple in the measurement and be useful in observations within the same individual.

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