STUDIES ON MYOCARDIAL CONTRACTILITY

—maxV_{CE} MEASURED WITH

USUAL CARDIAC CATHETERS

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It has been reported that the index maxV_{CE} which represents myocardial contractility, can be measured in clinical cases from the pressure patterns recorded by catheter-tip pressure transducers.

In this study the values of maxV_{CE} were calculated from the recordings obtained through a metal cannula inserted directly into the left ventricle and those obtained through an usual catheter connected directly to a pressure transducer on animal experiments.

A high significance of correlation (r = 0.98) was observed between these values obtained by two different methods, and it was concluded that intraventricular pressure and dp/dt patterns accurate enough to allow the calculation of maxV_{CE} could be obtained by usual catheters connected to pressure transducers directly.

The evaluation of the contractility of cardiac muscle beside the cardiac action as a pump is an important problem in deciding the treatment or the prognosis of clinical cases.

On the other hand, the maximal shortening velocity of the contractile element, i.e., maxV_{CE} has been said to represent myocardial contractility, excluding effects of preload and afterload.

Though the index has been noticed to be an ideal one to represent cardiac contractility based on strict experiments, the measurement of the index in clinical cases is not easy and the circumferential shortening velocity of the cardiac muscle, i.e., V_{CF} has been measured clinically.

Recently, however, the value of maxV_{CE} were calculated on clinical cases based on intraventricular pressure recordings.

On the other hand, in order to calculate maxV_{CE}, the detailed analysis of the isovolumetric phase of pressure and dp/dt patterns recorded with high fidelity recording system is required.

For this reason, a transducer-tipped catheter is ideal, but this method has several disadvantages: zero drift, breakage, valvular or endocardial damage and basic cost.

Considering the clinical meaning of maxV_{CE}, the index is desirable to be obtained during the routine cardiac catheterization procedure.

And some of the authors calculated the maxV_{CE} using usual cardiac catheters.

The purpose of this study is to compare the maxV_{CE} obtained from ideal pressure tracing with those obtained using an usual conventional catheter connected directly to a pressure transducer on animal experiments and to offer bases for evaluations of the index obtained with usual catheters.

METHODS

Five mongrel dogs weighing 10 to 20 kg were anesthetized with pentobarbital sodium (25 mg/kg) administered intravenously and the chests were opened on the left side under artificial
ventilation.

A polyethylene 8 F catheter of 70 cm length was inserted into the left ventricle through the right carotid artery and connected directly to a Statham P 23Db pressure transducer. A 20 gauge needle of 5 cm length was inserted into the left ventricle at the apex through pericardium and connected directly to a pressure transducer.

The over-all frequency response of the recording system using the cardiac catheter was 30 Hz and that of direct method was 100 Hz.

The pressure patterns thus obtained were differentiated through a differentiator* which offer dp/dt pattern (Fig. 1).

The calibration of dp/dt pattern was performed by feeding a linear saw tooth ramp of known slope to the differentiator11.

The shortening velocity of contractile element ($V_{CE}$) was obtained using the following equation:  

$$V_{CE} = \frac{dp/dt}{28p}$$

Intraventricular pressure ($p$) parallels to the ventricular tension ($T$) during the isovolumetric period according to Laplace's Law ($T = p.r/2$), because the radius ($r$) can be considered constant during this period.

Hence $max V_{CE}$ was derived from the plot relating $dp/dt/28p$ (ordinate) to corresponding left ventricular pressure $p$ (abscissa) which was extrapolated to zero pressure.

Plotting on several heart beats will make the

* Fukuda Electro Co. Differentiator

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Fig. 1. Pressure and dp/dt patterns, (A: direct method, B: transcatheter method.)

Fig. 2. $V_{CE}$ vs pressure. Plot of $V_{CE}$ and pressure during the isometric phase.

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<table>
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Table I: Data on myocardial contractility


$a$: before, $b$: during exercise. $x$: direct method, $y$: transcatheter method.

Fig. 3. Relation between $maxV_{CE}$ obtained with direct method and transcatheter method.

Before and after the manipulation.

**RESULTS**

Comparing the pressure and $dp/dt$ patterns obtained with two different methods, there are more notching or slurring in those obtained with transcatheter method.

However, patterns sufficient enough to allow the calculation of the index could be recorded by flushing catheters and selecting proper position of the catheter tip amid the ventricle.

The values obtained with these different methods were well consistent with each other.

As shown in Table I, $maxV_{CE}$ and $max \, dp/dt$ were decreased or unchanged by administration of methoxamine, propranolol, or volume load and increased by isoproterenol. There were no differences in these tendencies in either method.

When $max \, dp/dt$ obtained with transcatheter method was compared with those obtained with direct method, a high coefficient of correlation and little scatter were observed ($r = 0.98$).

The mean value of $maxV_{CE}$ in resting condition obtained with direct method was $1.55 \pm 0.36$ circ./sec and that obtained with transcatheter method was $1.57 \pm 0.37$ circ./sec.

Relationship between $maxV_{CE}$ obtained in
these two methods is shown in (Fig. 3). A high coefficient of correlation \( r = 0.98 \) was observed and the ratio of their mean values was 0.99.

**DISCUSSION**

The evaluation of the contractility of cardiac muscle is an important problem today, and the maximal shortening velocity of contractile element \( \text{max} V_{CE} \) has been indicated as an ideal index for this purpose.

In order to calculate \( \text{max} V_{CE} \) in clinical cases, accurate pressure and dp/dt patterns of isovolumetric phase are necessary preferably with transducer-tipped catheters.

On the other hand, considering the clinical meaning of the index, more easily available methods are desirable.

As the duration of isovolumetric period ranges 50 to 100 msec and corresponds to changes of 10 cycle/sec, these changes may be followed by recording system of 30 Hz frequency response.

The results mentioned above indicate that intraventricular pressure and dp/dt patterns are accurate enough to allow the calculation of \( \text{max} V_{CE} \), provided a pressure transducer is connected to the catheter which is flushed repeatedly and the tip of which is set at proper portion of the ventricle.

And this result was not altered when the hemodynamic states were changed by several kinds of manipulations.

Finally, as animals were not denervated, the effects of the manipulations were modified by neurohumoral factors.

It is not important problem in this study, because the primary purpose was to observe the changed hemodynamic states and not to observe the effects of pure pressure or volume loading.

**CONCLUSION**

It was concluded that intraventricular pressure and dp/dt patterns which are accurate enough to allow the calculation of \( \text{max} V_{CE} \) could be obtained by usual cardiac catheterization method.

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**REFERENCES**