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SUMMARY

To determine the left ventricular ejection time by noninvasive examination of the heart, measurement from the carotid pulse has been used. As simplification of this complicated method is desirable, for mass survey of large populations, the correlations of the left ventricular ejection time sought from the carotid differential pulses, and the left ventricular ejection time sought from the carotid pulse and aortic valve echo were studied in 34 cases. Good correlations were observed with coefficients of 0.97 ($P<0.01$) and 0.95 ($P<0.01$), respectively. Therefore, it can be expected that measurement of the left ventricular ejection time from the carotid differential pulses can be practically applied as a simplified method in mass surveys. Use of differential pulse will also enable auto-analysis by computer, which not only would be applicable in mass surveys, but perhaps would become a very effective means of observing changes in left ventricular ejection time in pharmacological intervention, etc.

INTRODUCTION

The method of seeking the left ventricular ejection time from the carotid pulse is known to have a good correlation with the invasive measurement, and it has been used in routine clinical practice and research as an useful procedure for evaluating the left ventricular function.[1-6] Measuring left ventricular ejection time from the carotid pulse is relatively

要 約

非観血的心臓検査法による左室駆出時間の計測としては，頸動脈波からの測定が行われてきた．大規模な集団を対象とした mass survey においては，この方法はその計測法が繁雑であるので簡略化が望まれる．この簡略化を目的として，頸動脈波の微分波から求めた左室駆出時間と頸動脈波及び大動脈弁エコーから求めた左室駆出時間の相関性を34例について検討した．相関係数はそれぞれ0.97 ($P<0.01$)，0.95 ($P<0.01$) であり，良い相関性が認められた．したがって，mass survey における左室駆出時間計測簡略化の方法として，微分波からの左室駆出時間の測定は実用化が期待できると考えられる．同時に微分波の使用により，コンピューターによる自動解析も可能となり，mass survey に応用できるだけでなく薬物負荷等に対する左室駆出時間の変化を観察する上で，極めて有力な手段となり得ると考えられる．

緒 言

左室駆出時間を頸動脈波から求める方法は，観血的左室駆出時間計測法と良い相関性を示すことが知られ，左心機能を評価する優れた方法として日常の臨床及び研究面で使用検討されている．[1-6] 頸動脈波からの左室駆出時間測定の方法は，少数の被検者を

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convenient for a small number of examinees, but it has the disadvantage of being too complicated for use in mass surveys and in measuring many heart beats even in a small population. To simplify the method of measurement, we have determined the left ventricular ejection time from the carotid differential pulse and studied the correlation.

MATERIALS AND METHODS

The 34 subjects of this study consist of 15 heart disease cases, 10 nonheart disease cases, and 9 normal persons, for whom measurements of the aortic valve echo, carotid pulse, and carotid differential pulses were all satisfactorily recorded. Their ages ranged from 9 to 80.

The apparatuses used were an Echoline 20 (Smith Kline Inc.), a polygraph (Electronics for Medicine Inc.), and a 2.25 MHz heart echo transducer 15 mm in diameter with a repeat pulse of 1,000 Hz.

The examinee was placed in a supine position and the aortic valve echo was detected by placing the heart echo transducer on the left margin of the sternum in the third intercostal space and directing the beam inside and upward.[7,8] At the same time, an electrocardiogram (ECG) was taken and the carotid pulse and the carotid differential pulse were recorded on a strip chart. A paper speed of 100 or 200 mm/sec was used. The primary (first time derivative of carotid pulse) and the secondary (second time derivative of carotid pulse) carotid differential pulses were recorded, and two types of wave forms were recorded for the secondary differential pulse using a 2,500 Hz filter and a 20 Hz filter.

The left ventricular ejection time was sought from the carotid pulse (ETcp) by measuring the time from the starting point of the upstroke to the dicrotic notch.[1] For the primary differential pulse (ETdp/dt), the left ventricular ejection time was obtained by measuring the time interval between the starting point of the upstroke and the nadir of the end systolic wave. For the secondary differential pulse, the left ventricular ejection time was obtained by measuring the time interval between the early systolic peak and the peak of the positive wave of the end systolic wave. Two kinds of left ventricular ejection time measurements were sought from the secondary differential pulse, one using a 2,500 Hz filter

対象とする場合には比較的簡便であるが，多数を対象とした mass survey や，少数の集団においても多数の心拍を測定する上では，その測定方法は繁雑となるきらいがある．今回，我々はこの測定方法の簡便化を目的として，頸動脈波の微分波から左室駆出時間を求め，その相関性について検討した．

材料及び方法

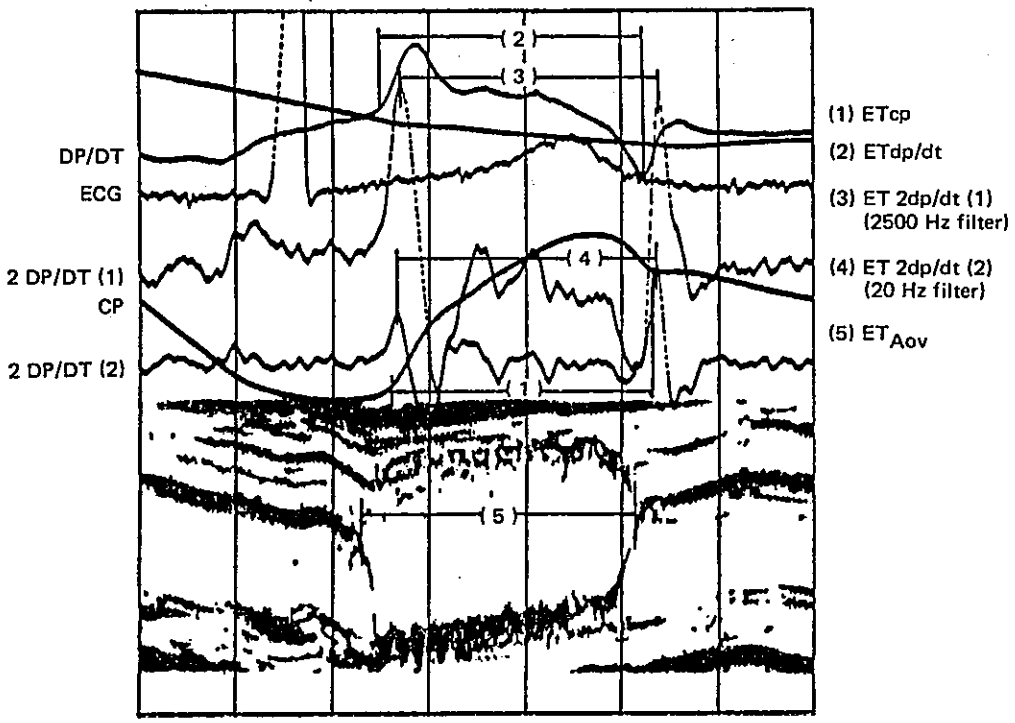
対象は測定条件として大動脈弁エコー，頸動脈波及びその微分波が同時に良好に記録された心疾患15例，非心疾患10例及び健常者9例よりなる34例である．年齢構成は9歳から80歳までであった．

使用した装置は Smith Kline 社製 Echoline 20及び Electronics for Medicine 社製 polygraph で，心エコー用トランスデューサーは2.25 MHz，直径15mm，繰り返しパルス1,000 Hz のものを用いた．

記録は被検者を安静仰臥位にして，心エコー用トランスデューサーを第3肋間胸骨左縁に置き，ビームを内側上方に向け大動脈弁エコーを検出した．[7,8] 同時に心電図，頸動脈波及びその微分波をストリップチャートに記録した．ペーパー・スピードは100又は200mm/sec を用いた．頸動脈波の微分波は1次及び2次微分波を記録し，2次微分波については，それぞれ2,500 Hz フィルターと20 Hz フィルターを使用した2種の波形を記録した．

頸動脈波からの左室駆出時間は，頸動脈波（ETcp）の upstroke 開始点から dicrotic notch までを計測して求めた．[1] また1次微分波（ETdp/dt）については，upstroke 開始点と end systolic wave の nadir までの区間を測定して左室駆出時間とした．2次微分波については，early systolic と end systolic wave の positive wave のピーク間を測定することによって左室駆出時間とした．2次微分波からの左室駆出時間については，2,500 Hz フィルターを使用した

FIGURE 1 METHOD OF MEASUREMENT
図1　測定の方法



(ET2dp/dt (1)) and the other using a 20 Hz filter (ET2dp/dt (2)). The left ventricular ejection time was sought from the aortic valve echo by measuring the time interval between the opening point and the closing point of the aortic valve echo (ETAov).[8] The measurements were made for five consecutive heart beats for each case (Figure 1).

もの（ET2dp/dt(1)）と20 Hzフィルターを使用したもの（ET2dp/dt(2)）の2種について求めた．大動脈弁エコーからは，大動脈弁エコー（ETAov）の opening point と closing point の2点間の区間を測定して，左室駆出時間を求めた．[8] 以上の計測を各症例につき，連続した5心拍について行った（図1）．

RESULTS

The correlation coefficient for ETAov and ETdp/dt was 0.951 ($P < 0.01$), for ETAov and ET2dp/dt(1) it was 0.959 ($P < 0.01$), and for ETAov and ET2dp/dt(2) it was 0.957 ($P < 0.01$) (Figure 2). Good correlations were evident for the left ventricular ejection time sought from the carotid pulse and the carotid differential pulse. The correlation coefficient for ETcp and ETdp/dt was 0.975 ($P < 0.01$), for ETcp and ET2dp/dt(1) it was 0.977 ($P < 0.01$), and for ETcp and ET2dp/dt(2) it was 0.973 ($P < 0.01$) (Figure 3).

The mean error between the measured values (Table 1) was 4.76 ± 1.08 msec between ETAov

結　果

ETAov と ETdp/dt の相関係数は0.951（$P < 0.01$）であり，ETAov と ET2dp/dt(1) の相関係数は0.959（$P < 0.01$），ETAov と ET2dp/dt(2)のそれは0.957（$P < 0.01$）であった（図2）．頸動脈波と微分波から求められた左室駆出時間についても良い相関性が認められた．ETcp と ETdp/dt の相関係数は0.975（$P < 0.01$）であり，ETcp と ET2dp/dt(1) の相関係数は0.977（$P < 0.01$），ETcp と ET2dp/dt(2) のそれは0.973（$P < 0.01$）であった（図3）．

各測定値間の平均誤差（表1）は ETAov と ETdp/dt

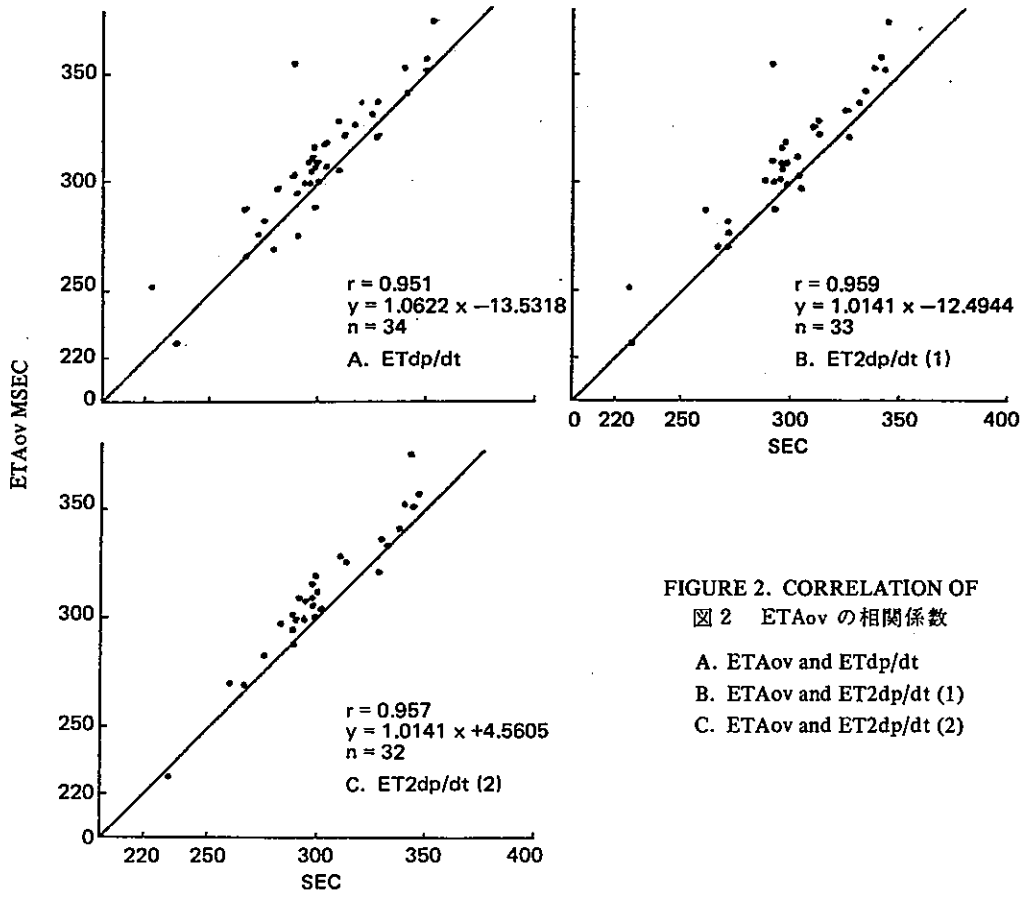


FIGURE 2. CORRELATION OF
図 2　ETAov の相関係数

A. ETAov and ETdp/dt
B. ETAov and ET2dp/dt (1)
C. ETAov and ET2dp/dt (2)

TABLE 1 CORRELATION COEFFICIENTS AND MEAN ERRORS
表 1　相関係数及び平均誤差

	CP-DP/DT	CP-2DP/DT(1)	CP-2DP/DT(2)	Aov-DP/DT	Aov-2DP/DT(1)	Aov-2DP/DT(2)
r	0.975	0.977	0.973	0.951	0.959	0.957
Average Difference*	2.42 ± 0.70	5.57 ± 0.65	5.44 ± 0.77	4.76 ± 1.08	7.97 ± 0.99	8.02 ± 0.98

**Average difference between values obtained by two methods.*　二つの方法による測定値の差の平均.

and ETdp/dt, 7.97 ± 0.99 msec between ETAov and ET2dp/dt(1), and 8.02 ± 0.98 msec between ETAov and ET2dp/dt(2). It was 2.42 ± 0.7 msec between ETcp and ETdp/dt, 5.75 ± 0.65 msec between ETcp and ET2dp/dt(1), and 5.44 ± 0.77 msec between ETcp and ET2dp/dt(2).

DISCUSSION

The left ventricular ejection time calculated from the carotid pulse as a noninvasive method cor-

では4.76±1.08msec, ETAov と ET2dp/dt(1) では7.97±0.99msec, ETAov と ET2dp/dt(2) では8.02±0.98msec であった. またETcp とETdp/dt 間の平均誤差は2.42±0.7msec, ETcp と ET2dp/dt(1) では5.75±0.65msec, ETcp と ET2dp/dt(2) では5.44±0.77msec であった.

考　察

非観血的計測法として頸動脈波から算出された左室駆出時間は, 観血的に求められた左室駆出時間と

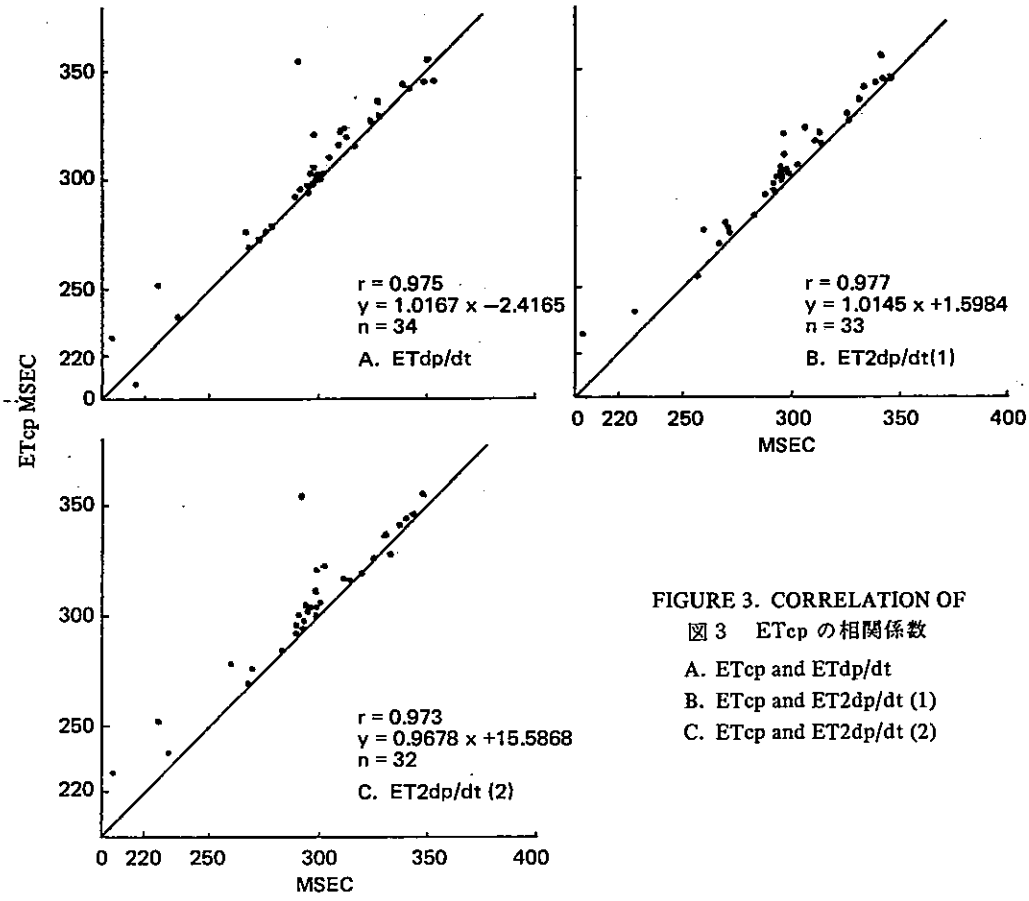


FIGURE 3. CORRELATION OF
図3　ETcp の相関係数

A. ETcp and ETdp/dt
B. ETcp and ET2dp/dt (1)
C. ETcp and ET2dp/dt (2)

related well with that obtained invasively.[1,2,4-6] Measurement of this ejection time by the carotid pulse can be a good index for evaluating the left ventricular function, but has the disadvantage of being complicated for use in mass surveys and simplification is desired. Application of carotid primary differential pulse as a tentative method to this end has been reported[9] but we have studied the possibility of applying both primary and secondary differential pulses in the measurement of left ventricular ejection time. In the present study, every differential pulse showed a good correlation to both ETcp and ETAov, but ET2dp/dt(1) showed the best correlation to both ETcp and ETAov. This is probably attributable to the difficulty of establishing the starting point of the upstroke in the measurement of the primary differential pulse and the mixing due to low filtering of elements other than the carotid pulse in the measurement of the secondary differential pulse using a 20 Hz filter. It is considered that the most satisfactory correlation was demonstrated in the measurement of the

非常に良い相関性を示す.[1,2,4-6] 頚動脈波による左室駆出時間の測定は，左心機能を評価する上で良い指標となり得るが，多数の被検者を対象とする mass survey においてはその測定方法は繁雑であり簡略化が望まれる．これまでにその試みとして頚動脈波1次微分波を応用した報告[9]があるが，我々は1次微分波，2次微分波の両方について左室駆出時間測定への応用の可能性を検討した．今回の検討では各微分波ともに ETcp と ETAov の両方に対し良い相関性を示したが，ET2dp/dt(1) は ETcp と ETAov の両方に対して最も良い相関性を示した．これは，1次微分波の測定においては upstroke 開始点の取り方に難点があり，20 Hz フィルター使用の2次微分波の測定においては low filter のために頚動脈波以外の要素が混在してくるためと考えられる．2,500 Hz フィルター使用の2次微分波については，その

secondary differential pulse using a 2,500 Hz filter owing to the clarity of the points of measurement, these being the early systolic peak and the peak of the positive wave of the end systolic wave, and the removal of elements other than the carotid pulse by high filtering. In view of the above, it seems that application of the carotid differential pulse to measurement of the left ventricular ejection time is fully possible and that use of the secondary differential pulse employing a 2,500 Hz filter is the most suitable method.

測定点が early systolic と end systolic wave の positive wave の各ピークであるという測定上の明確さとともに high filter により頚動脈波以外の要素が除去されるため，最も良い相関性を示したものと考えられる．以上の点から，頚動脈微分波の左室駆出時間測定への応用は十分可能なものであり，2,500 Hz フィルター使用の２次微分波が最適であると考えられる．

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