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RELATIONSHIP BETWEEN AORTIC VALVE CLOSURE AND SECOND HEART SOUND

大動脈弁閉鎖とⅡA音の関連性について

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SUMMARY

The relationship between aortic valve closure (AVC) and second (IIA) heart sound was sought by simultaneous echocardiographic, phonocardiographic, and electrocardiographic recordings of the aortic valve in 35 persons including 10 normal cases, 15 heart disease cases and 10 nonheart disease cases, ranging in age from 11 to 82 years. Five heart beats each were measured. The overall mean interval from point of coaptation of the aortic valve at the end of systole to onset of IIA sound (AVC-IIA interval) was 10.4 msec with 1 case less than 5 msec, 15 cases between 5 msec-10 msec, 15 cases between 10 msec-15 msec, and 4 cases over 15 msec. No difference was noted between the normal, the heart disease, and the nonheart disease cases. Onset of IIA sound was not coincident with the point of AVC, but the peak of the sound appeared immediately after the point of coaptation, showing that IIA sound is very closely related to AVC.

INTRODUCTION

There is as yet no established theory on the question of whether AVC and onset of the IIA sound are coincident.[1] It has been reported that the IIA sound originates in the closing of the semilunar valves.[2,3] Recently, Criley et al[4] observed on cineangiography that the IIA sound occurs several milliseconds after AVC. MacCanon et al[5] also suggested that the IIA sound did not originate in the closing of the aortic valve tip. In recent years, ultrasound

要 約

大動脈弁閉鎖(AVC)とⅡA音の関係を大動脈弁エコー，心音図及び心電図の同時記録で35例について調べた．すなわち11歳から82歳までの健常10例，心疾患15例，非心疾患10例について5心拍ずつを計測した．収縮期終末の大動脈弁の閉鎖接点からⅡA音発生までの間隔は5 msec未満が1例，5 msec～10msecが15例，10msec～15msecが15例，及び15 msec以上が4例あり，平均は10.4msecであった．健常者と心疾患，非心疾患者の間には差を認めなかった．ⅡA音は大動脈弁閉鎖の接点と一致しないが，ⅡA音のピークは大動脈弁閉鎖の接点の直後に現れ，大動脈弁閉鎖と極めて関係が深い．

緒 言

大動脈弁閉鎖とⅡA音が一致するという定説はまだない．[1] 従来，ⅡA音は半月弁閉鎖に由来すると報告されている．[2,3] 最近Criley ら[4] はシネアンジオグラフィによりⅡA音が大動脈弁閉鎖数msec後に起こることを認めた．またMacCanon[5] もⅡA音は大動脈弁尖の閉鎖に由来するものでないことを示唆している．近年非観血的心臓検査法としての超音波検査

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cardiography (UCG or Echo) has become widely used as a method of noninvasive heart examination in diagnosis and research, because it presents the movements of heart blood vessels and valves as characteristic wave patterns which are measurable. We have used UCG and phonocardiography to study the relationship between AVC and onset of the IIA sound in 35 normal, heart disease, and nonheart disease cases.

MATERIALS AND METHODS

The 35 subjects studied included 10 normal, 10 nonheart disease, and 15 heart disease cases, ranging in age from 11 to 82 years (Tables 1-3). The 10 nonheart disease cases included 4 of anemia, 3 of diabetes mellitus, 2 of tuberculosis, and 1 case of emphysema (Table 2). The 15 heart disease cases included 3 individuals with aortic insufficiency, 4 persons with hypertensive cardiovascular disease, 2 cases of mitral stenosis, 1 case each of aortic insufficiency + mitral stenosis, mitral stenosis + aortic stenosis, and idiopathic hypertrophic subaortic stenosis, and 3 cases of other heart diseases (Table 3). Satisfactory simultaneous echocardiographic, phonocardiographic, and electrocardiographic recordings were obtained for all cases.

（UCG 又は Echo ）は，心血管並びに各弁膜の動きを特徴的な波型で現し，その測定が可能であるため，診断と研究に広く役立つようになった．我々は UCG と心音図を用いて健常，心疾患，非心疾患の35例について大動脈弁閉鎖とⅡA 音発生との関係を調べた．

対象者及び方法

対象者は11歳から82歳までの健常10例，非心疾患10例，心疾患15例からなる35例である（表１－３）．非心疾患10例は貧血症４例，糖尿病３例，結核２例及び肺気腫１例を含む（表２）．心疾患15例には大動脈弁閉鎖不全３例，高血圧性心疾患４例，僧帽弁狭窄症２例，大動脈弁閉鎖不全＋僧帽弁狭窄症 １例，僧帽弁狭窄＋大動脈弁狭窄症１例，特発性肥大性大動脈弁下狭窄症１例及びその他の心疾患３例が含まれる（表３）．全例について大動脈弁エコー，心音図及び心電図の良好な同時記録が得られた．

TABLE 1 ECHOCARDIOGRAPHIC DATA OF NORMAL CASES
表１　正常例における心エコー図データ

Patient	Age	AVC-IIA Interval
MF [redacted]	53	9.2 msec
MF [redacted]	11	15.3
MF [redacted]	48	7.5
MF [redacted]	26	11.2
MF [redacted]	44	12.3
MF [redacted]	55	10.1
F [redacted]	54	11.8
MF [redacted]	18	9.3
MF [redacted]	27	7.0
MF [redacted]	26	12.5

Apparatus and Recording Method

Recordings were made using the Echoline 20 manufactured by the Smith Cline Company and a polygraph manufactured by the Electronics for Medicine Company. In this procedure, a 2.25 MHz flat transducer 15 mm in diameter with a repetition rate of 1,000 impulses/sec,

装置及び記録方法

記録はSmith Cline 社製の Echoline 20及び Electronics for Medicine 社製の polygraph を用いた．2.25MHz，直径15㎜，反復回数1,000impulses/sec の平面探触子

TABLE 2 CLINICAL AND ECHOCARDIOGRAPHIC DATA OF NONHEART DISEASE PATIENTS
表2　非心疾患例における臨床データ及び心エコー図データ

Patient	Age	Diagnosis	AVC-IIA Interval
MF [redacted]	54	Anemia	8.4 msec
MF	47	Diabetes mellitus	10.5
MF	43	Diabetes mellitus	13.4
MF	32	Tuberculosis	16.3
MF	63	Diabetes mellitus	11.7
MF	62	Tuberculosis	9.7
MF	50	Anemia	9.4
MF	42	Anemia	7.1
MF	53	Emphysema	10.2
MF	71	Anemia	7.4

TABLE 3 CLINICAL AND ECHOCARDIOGRAPHIC DATA OF HEART DISEASE PATIENTS
表3　心疾患例における臨床データ及び心エコー図データ

Patient	Age	Diagnosis	AVC-IIA Interval
MF [redacted]	57	Aortic insufficiency	14.6 msec
MF	31	Aortic insufficiency	5.8
MF	66	Aortic insufficiency + Mitral stenosis	6.7
MF	67	Mitral stenosis + Aortic stenosis	16.2
MF	59	Hypertensive cardiovascular disease	15.9
F	58	Ischemic heart disease	12.0
MF	77	Mitral stenosis	5.8
MF	82	Hypertensive cardiovascular disease	10.7
MF	60	Mitral stenosis	9.4
MF	82	Aortic insufficiency	9.5
W	42	Arteriosclerotic disease	3.2
MF	53	Hypertensive cardiovascular disease	12.8
MF	73	Hypertensive cardiovascular disease	7.6
MF	16	Congenital heart disease	11.2
MF	16	Idiopathic hypertrophic subaortic stenosis	13.2

was placed on the third intercostal space at the left margin of the sternum of the examinee at rest in supine position; the beam was directed in a somewhat inward and upward direction; and aortic valves which presented an M-mode scan at the base of the aorta were selected. Phonocardiography was done placing a piezoelectric microphone on the sternum at the left margin of the second intercostal space using a

により，安静仰臥位の被検者の第3肋間胸骨左縁にビームを入射し，やや内側上方に向け，大動脈基部にM-mode scanを呈した大動脈弁を選んだ．心音図は周波数が50Hzから500Hzのpiezoelectric microphoneを胸骨第2肋間左縁に設置し，これと同時に

frequency of 50 Hz to 500 Hz, and simultaneously with this electrocardiographic and carotid artery pulse waves were recorded on strip paper at a speed of 100 mm/sec or 200 mm/sec.

Measurement

For each case five heart beats were selected for measurement where the point of coaptation in AVC at the end of systole was satisfactorily recorded. The AVC - IIA interval was defined as the time from the point of coaptation in AVC to that of maximum amplitude of the IIA sound (Figures 1 and 2).

RESULTS

The mean values for the AVC - IIA intervals of five heart beats in the 10 normal cases ranged from 7 msec to 15.3 msec and the mean was 10.6 msec. No difference by age was evident (Table 1).

In the 10 nonheart disease cases, the intervals ranged from 7.1 msec to 16.3 msec, and the mean was 10.4 msec (Table 2). For the 15 cases with heart disease the mean interval was 10.3 msec, the shortest being 3.2 msec for arteriosclerotic disease and the longest, 16.2 msec for mitral stenosis + aortic stenosis. Idiopathic hypertrophic subaortic stenosis showed an interval of 13.2 msec with no marked prolongation (Table 3). The values of these two groups were consistent with those of the normal group.

DISCUSSION

Since the observations by Wiggers[2] in 1915 concerning the developmental mechanism of the IIA sound, it had been assumed that the sound had its origin in the vibrations caused by closure of the semilunar valves. However, a number of later studies showed that closure of the semilunar valves and occurrence of the IIA sound do not necessarily coincide. In 1962, Criley et al[4] found by cineangiography that valve closure occurs several milliseconds prior to the onset of the IIA sound. Spencer and Greiss[6] reported from their experiment with dogs that the IIA sound was temporally consistent with the aortic pressure incisura on electrocardiogram. In 1975, Chandraratna et al[7] showed by simultaneous echocardiographic, phonocardiographic, and electrocardiographic recording that IIA sound occurs later than AVC and that the AVC - IIA

心電図，頚動脈波をストリップペーパーに100mm/sec又は200mm/secの速度で記録した．

測　定

全例について収縮期終末の大動脈弁閉鎖接点が良好に記録されたものを5心拍ずつ選んで計測した．AVC-ⅡA間隔は大動脈弁閉鎖の接点からⅡA音の最大振幅までとした（図1及び2）．

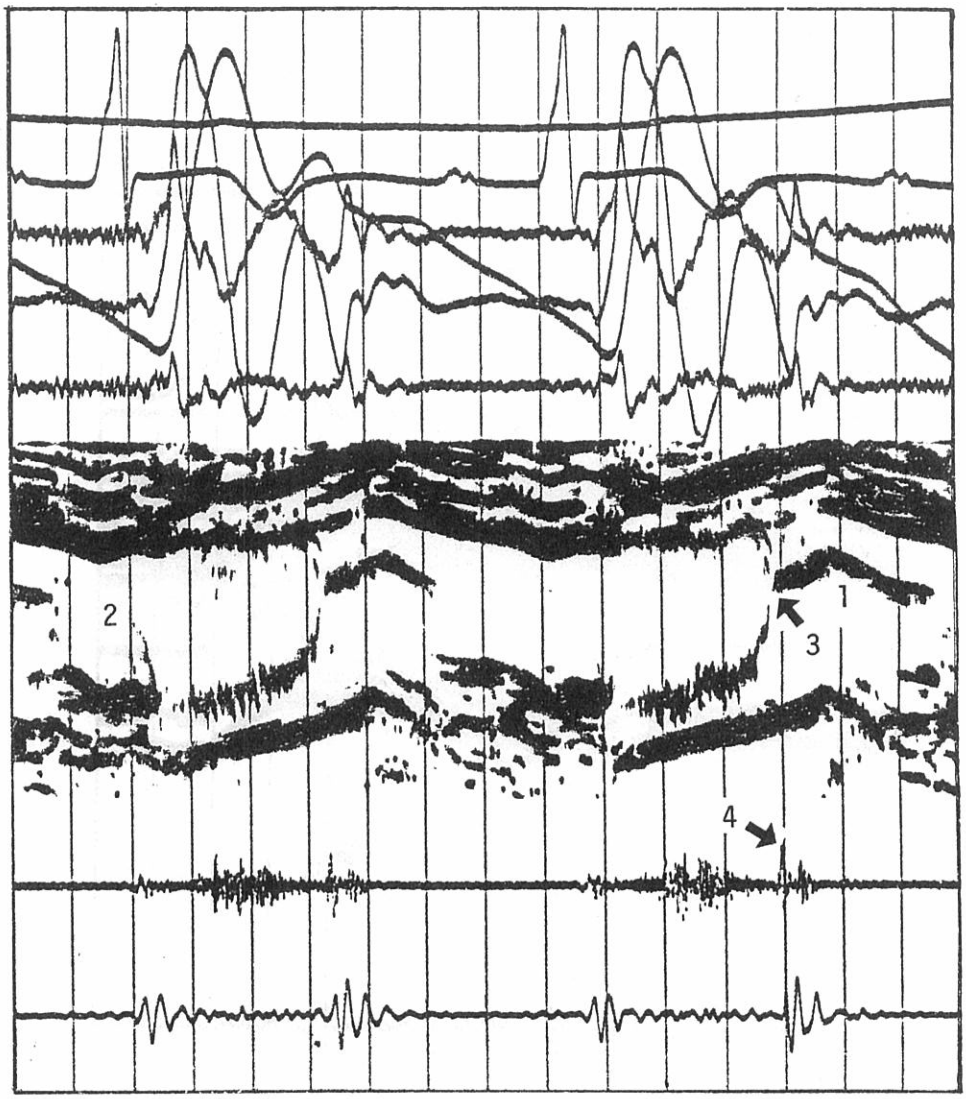
結　果

健常10例ではAVC-ⅡAの5心拍の平均値は7msecから15.3msecであり，平均値は10.6msecである．年齢による差は認められない（表1）．

非心疾患の10例ではその間隔は7.1msecから16.3msecまでであり，平均10.4msecであった（表2）．心疾患を有する15例の平均は10.3msecであり，そのうち動脈硬化症例が最小で3.2msec，最大は僧帽弁狭窄＋大動脈弁狭窄症例の16.2msecである（表3）．特発性肥大性大動脈弁下狭窄症例は13.2msecで著明な延長は認められなかった（表3）．これら両群の値は健常群とほとんど一致する．

考　察

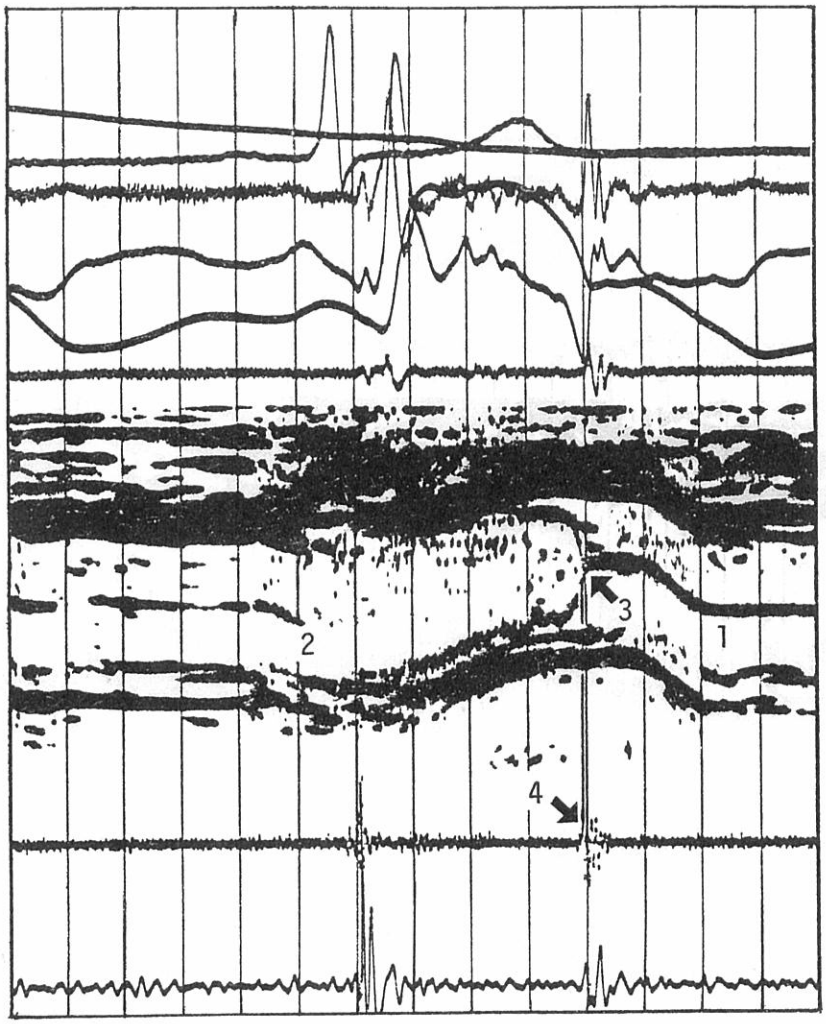
ⅡA音の発生機序については，Wiggers[2]による1915年の研究以来，半月弁閉鎖による振動がその起源であると想定されてきた．しかし，その後の研究では半月弁閉鎖とⅡA音は必ずしも一致しないことが明らかになった．1962年にCriley ら[4]はシネアンジオグラフィで弁閉鎖はⅡA音より数msec前に起こることを認めた．またSpencer及びGreiss[6]は犬を用いた実験で，ⅡA音は大動脈圧の心電図上の切れ込みと一致して起こると報告している．1975年にChandraratna ら[7]は心エコー図，心音図及び心電図の同時記録により，ⅡA音はAVCより遅れて発生することを示し，AVC-ⅡA間隔は5～25msec，平均



1 Aortic valve 大動脈弁
2 Aortic valve opening 大動脈弁開放
3 Aortic valve coarctation 大動脈弁閉鎖
4 IIA ⅡA音

Figure 1 Simultaneous recording of the electrocardiogram, external carotid pulse, phonocardiogram, and echocardiogram of the aortic root and aortic valve; IHSS

図1 心電図，外頚動脈波，心音図及び大動脈根並びに大動脈弁の心エコーの同時記録ー特発性肥大性大動脈下狭窄症



1 Aortic valve 大動脈弁
2 Aortic valve opening 大動脈弁開放
3 Aortic valve coarctation 大動脈弁閉鎖
4 IIA ⅡA音

Figure 2 Simultaneous recording of the electrocardiogram, external carotid pulse, phonocardiogram, and echocardiogram of the aortic root and aortic valve; normal case

図2 心電図，外頚動脈波，心音図及び大動脈根並びに大動脈弁の心エコーの同時記録ー正常例

intervals ranged from 5 msec to 25 msec with a mean of 12 msec. In 1977, Hirschfeld et al[8] studied measurements made by simultaneous recording of intracardiac phonocardiograms and micromanometric aortic root pressure tracings in addition to echocardiograms and phonocardiograms on 16 cases of congenital heart disease. They found that the AVC - IIA intervals ranged from 3 msec to 5 msec and suggested on the basis of intracardiac phonocardiography that IIA sound and aortic pressure incisura occur simultaneously. The AVC - IIA intervals in our normal and nonheart disease groups ranged from 7.1 msec to 16.3 msec and averaged 10.4 msec; those of the heart disease group ranged from 3.2 msec to 16.2 msec and averaged 10.3 msec. Thus little difference occurred among the three groups, and no marked prolongation was evident in the aortic stenosis and idiopathic hypertrophic subaortic stenosis cases. The measured intervals of Hirschfeld et al[8] were shorter than those of Chandraratna et al[7] and the authors, but this probably is due to difference in identification of the point of onset of the IIA sound. Danzig et al[9] reported that some variations result from the method of recording and that varying the paper speed causes time line interval differences. IIA sound occurs immediately after closure of the aortic valve, but, considering the time required for the transmission of the IIA sound to the phonocardiographic microphone, this does not necessarily negate a relationship between AVC and onset of the IIA sound. Indeed, the relation between the two is considered to be very close.

12msec であると報告した．一方1977年に Hirschfeld ら[8] は心エコー図，心音図のほかに心内心音図及び micromanometric aortic root pressure tracing の同時記録を用いて16人の先天性心疾患者に施行した測定で，AVC-ⅡA は３～５msec であり，心内心音図に基づきⅡA 音と大動脈圧波の深い切れ込みが同時に発生することを示唆した．我々の成績では健常群と非心疾患群の AVC-ⅡA は7.1～16.3msec，平均10.4msec であり，心疾患群では3.2～16.2msec，平均10.3msec である．この３群間の差はほとんどなく，大動脈弁狭窄症及び特発性肥大性大動脈弁下狭窄症例でも著明な延長を認めなかった．Hirschfeld ら[8] の測定値は Chandraratna ら[7] や我々のそれよりも短く，これはⅡA 音起始部固定の差によるものと思われる．Danzig ら[9] は記録法によって若干の差があり，またペーパースピードの変動により時間線間隔の差が生じることを報告している．ⅡA 音の発生は大動脈弁閉鎖直後からわずかに遅れて出現するが，これは心音マイクロホンまでのⅡA 音の伝達時間を考慮した場合，必ずしも大動脈弁閉鎖とⅡA 音発生の関連性を否定するものではない．したがって両者の関係は極めて深いと思われる．

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