Second Degree Sinoatrial Block with the Wenckebach Phenomenon Associated with Nodal Escape and Second Degree Atrioventricular Block and Its Conversion to Regular Sinus Rhythm by Sympathetic Stimulation ; Report of a Case*

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THE SINOATRIAL node may be involved in any pathologic process which affects the hearts. Arteriosclerosis, infarction, inflammation and degeneration can be etiologic factors in sinoatrial heart block. In cases without histopathologic changes in the sinoatrial node, functional disturbances such as increased vagal tone, metabolic alteration and drug intoxication may be important causes of sinoatrial heart block. Usually, sinoatrial heart block is asymptomatic so long as the lower pacemaker can resume cardiac beating, and clinical symptoms such as angina pectoris and the Adams-Stokes attack occur only when the lower pacemaker are also simultaneously depressed.

GREENWOOD and FINKELSTEIN¹ found 38 cases (17%) of second degree sinoatrial heart block with the Wenckebach phenomenon in 219 cases of all forms of sinoatrial heart block reported in the world literatures. Among the 38 cases, only 5 cases (13%) had clinically normal hearts. They indicated that sinoatrial heart block as well as the Wenckebach phenomenon occurs principally in diseased hearts. On the other hand, sinoatrial heart block in athletes reported by GALLAVARDIN^{2,3} and WHITE⁴ disappeared with exercise. Similar observations were made also in endurance athletes with second degree atrioventricular block with the Wenckebach phenomenon which disappeared after 100 meter dash⁵

A case is reported in which second degree sinoatrial heart block with the Wenckebach phenomenon was analyzed by applying the formulae

of SCHAMROTH and DOVE⁶ and converted to regular sinus rhythm by sympathetic stimulation.

REPORT OF A CASE

A 58-year-old male, an examiner of a court of justice entered the hospital on December 4, 1967 with a request of thorough examination of arrhythmia which was detected on a regular medical examination at his office. His past history was noncontributory except for his unusual devotion to recitation of Chinese poems for more than 40 years. The recitation of Chinese poems requires suppression of normal expiration to cause an increase in the intrathoracic pressure as in the Valsalva maneuver. He recites Chinese poems for about 2 hours daily. About 20 years before the admission, he was rejected by a part-time doctor of a life insurance company to insure his life because of his arrhythmia.

Physical examination revealed a well-nourished male with a rather florid countenance. He was 156 cm tall and weighed 57 kg. He had a slight difficulty in hearing due to otitis media chronica, but no discharge was observed. The chest was symmetrical with normal respiratory movements. On auscultation both inspiration and expiration were normal. The chest X-ray film showed normal pulmonary markings and normal cardiac configuration. Over the all valve areas, the heart sounds were clear, and there was neither splitting nor thrill. The cardiac rhythm was irregular at bed rest and regular for the first 5 to 10 minutes after bodily movements. Neither liver nor spleen

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Fig.1. The Wenckebach phenomenon in sinoatrial block.

Sinoatrial conduction is progressively prolonged from the 1st to 5th P waves with a progressive decrease in its increment and the PP interval. The 1st and 6th P waves (labeled P₁ and P₆, respectively) are the corresponding impulses,⁶ and the interval between them the isoconduction interval.⁶ The sinus cycle was calculated from the formula I of Schamroth and Dove.⁶

Fig.2. The Wenckebach phenomenon in sinoatrial block.

Gradual and progressive prolongation in sinoatrial conduction from the 3rd to the 9th P wave is followed by 2 successive sinoatrial blocks. The 3rd and 10th P waves (labeled P₃ and P₁₀, respectively) are the corresponding impulses, and the interval between them the isoconduction interval. The sinus cycle was calculated from the formulae I and II of Schamroth and Dove.

was felt on palpation. Fundoscopic examination demonstrated a slight increase in light reflex and slight changes at the arteriovenous crossing. There was neither motor nor sensory disturbance, and his consciousness, intelligence and speech were all normal.

LABORATORY REPORTS

Examination of the blood disclosed 101 per cent hemoglobin, 430×10^4 red blood cells and 8,200 white blood cells with a differential count of 73.5 per cent neutrophils and 2.5 per cent eosinophils. Examinations of urine and feces were normal. Icterus index was 5, alkaline phosphatase 6.7 King-Armstrong units, choline esterase 0.9 delta pH per hour, serum proteins 6.4 gm per 100 ml with an A/G ratio of 1.22, zinc turbidity test 11.0 Kunkel units, C.C.L.F. negative, cholesterol 195 mg per 100 ml. G.O.T. and G.P.T. were both less than 40 Sigma-Frankel units. C.R.P. and R.A.-test were both negative, and A.S.L.O. 125 Todd units. Serological tests for syphilis were all negative.

ELECTROCARDIOGRAPHIC OBSERVATIONS

All time intervals in the diagram are expressed in a hundredth of a second. In Fig.1, sinoatrial conduction is progressively prolonged from the 1st to 5th P waves with a progressive decrease in its increment and the PP interval. The 1st and 6th P waves (labeled P₁ and P₆, respectively) are "the corresponding impulses";⁶ and the interval between them "the isoconduction interval".⁶ The sinus cycle was calculated from the formula I of SCHAMROTH and DOVE.⁶ In Fig.2, sinoatrial conduction is gradually and progressively prolonged, and then 2 successive sinoatrial blocks ensued. The 3rd and 10th P waves (labeled P₃ and P₁₀, respectively) are the corresponding impulses, and the interval between them the isoconduction interval. The sinus cycle was calculated from the formulae I and II of SCHAMROTH and DOVE.⁶ In Fig.3, various arrhythmias caused by sinoatrial and atrioventricular blocks and nodal escapes are demonstrated. In panel 1, the 5th and 9th P waves (labeled P₅ and P₉, respectively) are the corresponding impulses. The interval between

Fig.3. The Wenckebach phenomenon in sinoatrial block associated with nodal escape and second degree atrioventricular block.

In panel 1, the 5th and 9th P waves (labeled P5 and P9, respectively) are the corresponding impulses, and the interval between them the isoconduction interval. Sinoatrial heart block occurs before the 2nd corresponding impulse at the end of the preceding isoconduction interval. In panel 2, the 4th and 7th P waves (labeled P4 and P7, respectively) are the corresponding impulses. They are blocked, however, because of the refractory period due to the preceding nodal escapes which themselves compensate for sinoatrial heart block. The 9th QRS complex following a nodal escape is a sinus-conducted beat (labeled P8). In panel 3, the sinus cycle was calculated by the formulae I and II of Schamroth and Dove.⁶ On account of the successive occurrence of either sinoatrial or atrioventricular block, 6 consecutive nodal escapes appeared from the 1st to 6th QRS complexes, which formed a regular atrioventricular nodal rhythm.

Fig.4. The Wenckebach phenomenon in sinoatrial block associated with nodal escape and second degree atrioventricular block.

The 3rd to 5th QRS complexes are sinus-conducted beats. They are followed by 2 successive sinoatrial heart blocks and then by 4 successive nodal escapes which formed a regular atrioventricular nodal rhythm.

Fig.5. The Wenckebach phenomenon in sinoatrial block associated with nodal escapes and first and second degree atrioventricular blocks.

On account of the absolute refractory period due to the preceding nodal escapes, the P waves labeled P₂ and P₇ are blocked. The P wave labeled P₅ which follows a nodal escape and probably occurs in the relative refractory period is conducted with a prolonged PQ interval of 0.40 sec. The PQ interval of a normally conducted beat is 0.12 sec.

Fig.6. The Wenckebach phenomenon in sinoatrial block associated with nodal escapes and first and second degree atrioventricular blocks.

The 3rd QRS complex is a sinus-conducted beat with a prolonged PQ interval of 0.32 sec. The interval between the 1st nodal escape (2nd QRS complex) and the 2nd conducted P wave (labeled P₂) is 0.28 sec, and that between the 2nd nodal escape (5th QRS complex) and the 4th blocked P wave (labeled P₄) is 0.16 sec. This indicated that the P wave occurs in the relative refractory period in the former and in the absolute refractory period in the latter.

them is the isoconduction interval. Sinoatrial heart block occurs before the 2nd corresponding impulse at the end of the preceding isoconduction interval. In panel 2, the 4th and 7th P waves (labeled P₄ and P₇, respectively) are the corresponding impulses, and the interval between them is the isoconduction interval. However, the P₄ and P₇ waves are blocked because of the refractory period due to the preceding nodal escapes which themselves compensate for sinoatrial heart block. The 9th QRS complex following a nodal escape is a sinus-conducted beat. The P wave (labeled P₈) is overlapped with the apex of the negative

T wave of the preceding nodal escape. In panel 3, the sinus cycle was calculated by the formulae I and II as proposed by SCHAMROTH and DOVE.⁶ On account of the successive occurrence of either sinoatrial or atrioventricular heart block, the pacemaker is shifted to the atrioventricular node. There are 6 consecutive nodal escapes from the 1st to 6th QRS complexes, which formed a regular atrioventricular nodal rhythm. Also in Fig.4, the pacemaker is shifted to the atrioventricular node from the 6th to 9th QRS complexes as a result of successive occurrence of either sinoatrial or atrioventricular block. In Fig.5, the

1 Effect of anxiety

a) Before electrode insertion for esophageal leads

b) Immediately after electrode insertion into the esophagus

2 Effect of alotec (isoproterenol derivative)

a) Before alotec injection

b) About 15 minutes after alotec injection

3 Effect of exercise

a) Before walking

b) Immediately after 15 minutes of walk with quick steps

Fig.7. Effects of sympathetic stimulation by anxiety, alotec (orciprenaline) and exercise.

An increase in sympathetic tone by mental tension during insertion of an electrode into the esophagus (panel 1), 0.5 mg of alotec injection (panel 2) and walking with quick steps (panel 3) abolished sinoatrial heart block with the Wenckebach phenomenon and induced a regular sinus rhythm.

P waves following nodal escapes labeled P_2 and P_7 are blocked, and that labeled P_5 conducted. On account of the relative refractory period due to the preceding nodal escape, the PQ interval which is normally 0.12 sec is prolonged to 0.40 sec in P_5 . In general, the P wave is blocked when it comes on the ST segment and the upstroke

(downstroke) of the positive (negative) T wave and conducted when it comes on the apex and downstroke (upstroke) of the positive (negative) T wave. In Fig.6, the 3rd QRS complex is a sinus-conducted beat associated with a prolonged PQ interval of 0.32 sec. As illustrated in the diagram, the interval between the 1st nodal escape

(2nd QRS complex) and the 2nd P wave (labeled P₂) which is conducted (0.28 sec) is longer than that between the 2nd nodal escape (5th QRS complex) and the 4th P wave which is blocked (0.16 sec). The P wave probably occurs in the relative refractory period in the former and in the absolute refractory period in the latter. In Fig. 7, the effects of various sympathetic stimulation are demonstrated. In panel 1, mental tension and anxiety during insertion of an electrode into the esophagus might have increased the sympathetic tone, and the esophageal leads taken immediately after insertion of an electrode showed a regular sinus rhythm. In panel 2, an increase in the sympathetic tone by alotec (isoproterenol derivative) also induced a regular sinus rhythm. In panel 3, an increase in the sympathetic tone caused by walking with quick steps induced also a regular sinus rhythm. The patient suffered from palpitation during the regular sinus rhythm and was relieved of it with reappearance of sinoatrial heart block. When second degree sinoatrial heart block was associated with the Wenckebach phenomenon, the sinus cycle ranged from 1.02 to 1.06 sec. After sympathetic stimulation, it ranged between 1.08 and 1.36 sec with a regular sinus rhythm. This may indicate that when the sinoatrial node has not sufficiently recovered before the next sinus impulse because of an increase in the sinus rate, the sinoatrial conduction is progressively prolonged and then finally blocked. The sympathetic stimulation may facilitate the sinoatrial conduction and in consequence decrease the sinus rate because sinoatrial heart block which probably necessitates an increase in the sinus rate is abolished by enhanced sinoatrial conduction. Disappearance of the arrhythmia by sympathetic stimulation and its reappearance at rest indicate a functional nature of the arrhythmia rather than an organic. Persistence of the arrhythmia without subjective symptoms for more than 20 years also indicates an

adaptive nature of the arrhythmia to daily recitation of Chinese poems which causes an increase in the intrathoracic pressure as in the Valsalva maneuver. Like endurance athletes, the patient may be in a state of sympathicotonia when he recites Chinese poems and in a state of training or rebound vagotonia when he rests.

SUMMARY

A 58-year-old male who recited Chinese poems for more than 40 years and had arrhythmia for more than 20 years showed second degree sinoatrial heart block with the Wenckebach phenomenon at rest. The arrhythmia was complicated by nodal escape and second degree atrioventricular block. The arrhythmia disappeared after muscular work and reappeared after more than 10 minutes of rest in a sedentary or recumbent position. It disappeared also after an injection of 0.5 mg of alotec (isoproterenol derivative). Functional and adaptive natures of the arrhythmia were indicated.

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