RECOVERY FROM COMPLETE HEART BLOCK IN DIPHTHERIA

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The development of complete heart block in the course of diphtheria has long been associated with an extremely grave prognosis. It has been considered almost invariably fatal, and the reported instances of recovery have been few.

Since the electrocardiogram came into general use and rendered certain the diagnosis of this conduction disturbance, there have been found in the literature 27 recoveries following complete heart block in diphtheria. Parkinson1 in 1915 by means of polygraphic tracings followed a patient who developed total heart block about the 22nd day of illness and auricular fibrillation a few days later. The block disappeared before discharge from the hospital, but the auricular fibrillation was still present after six months. Marvin and Buckley2 had one recovery among 11 cases of proven auriculoventricular dissociation. Mixsell3 found eight patients with total heart block among 400 cases of diphtheria. Three of these eight lived.

In 1932 Grunke4 reported one recovery out of 18 patients with AV dissociation. Frank5 likewise recorded the survival of one patient with complete heart block from a group of 11 with severe conduction disturbances. In Behr's6 series of 230 cases of malignant diphtheria, in which there was a 54% incidence of myocarditis, there was one patient whose total heart block subsided after two or three days, another whose block disappeared after a few minutes, and a third who lived following the development of varying degrees of partial and complete block. Four of Begg's7 12 cases of total AV dissociation survived, but only one patient recovered among the 33 with complete heart block in the experience of Rissotto, Natin, and da Rin.8 Fishberg9 stated that he had seen only one such case survive.

Neubauer10,11 studied 16 patients with AV dissociation. Two of these survived. One of them had auricular fibrillation as well. Giraud12 and his coworkers commented that they had observed two patients in whom the complete heart block was not fatal. The largest number of recoveries was reported by Schweitzer13 in 1946: seven of his 30 patients with complete AV dissociation lived. Some of this group had heart blocks which were only a few seconds in duration.

In addition there were several reports (Alstead,14 Bates,15 and Schweitzer13) of patients in whom the complete heart block disappeared but who succumbed shortly afterward to other complications of diphtheria.

Even among the writers who reported recoveries from total heart block, the mortality was still quite high, ranging from 63% (Mixsell) to 97% (Rissotto et al), with an average mortality rate from complete heart block in diphtheria of 90%. On the other hand there were a number of studies in which the mortality was 100%.

McCulloch16 in 1920 reported 100% fatality in the group which showed interference

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in the conduction system. Smith\textsuperscript{17} the year following found that all of his patients with total AV dissociation died. There were 11 such among the 242 patients with diphtheria in this survey. Schwensen\textsuperscript{18} mentioned 11 patients with an early irregularity in the heart rhythm in the group of 568 cases of diphtheria that he studied. The disturbance in rhythm proved fatal for all 11. None of Loth's\textsuperscript{19} patients recovered from high grade heart block. Stecher\textsuperscript{20} described 19 cases of AV dissociation, all of them fatal. Burkhardt, Eggleston, and Smith\textsuperscript{21} had 11 patients with complete heart block in a group of 17 patients with conduction changes. All 11 died.

Because the mortality from this complication of diphtheria is so high and the recoveries so few, it seems worth while to report these six patients who developed AV dissociation during the course of diphtheria and who are now well. They were admitted to Sydenham Hospital between October 1, 1945 and April 1, 1947. During these 18 months there were 554 patients with diphtheria in Sydenham Hospital. The clinical impression of diphtheria was substantiated in each patient by positive cultures of \textit{C. diphtheriae}. The patients were examined daily for evidence of myocarditis, and electrocardiograms were taken on admission and at frequent intervals throughout the hospital stay. The incidence of myocarditis in this group was 45\%, and the mortality from myocarditis was 4\%. Thirteen patients developed complete heart block, and six of these recovered.

![Lead I](image1.png)

![Lead II](image2.png)

![Lead III](image3.png)

\textbf{Fig. 1A.} D. T., 9th day of illness. Complete AV dissociation and depression of ST 2 and 3. Auricular rate 116/min. ventricular rate 58/min.

\textbf{Fig. 1B.} D. T., 150th day after onset. Normal sinus rhythm, right axis deviation, diphasic T 2 and inverted T 3. Rate 122/min., PR 0.12 sec., QRS 0.08 sec.
Case Reports

Case 1. D. T. (33600 and 33670), a 5-year-old white boy, was admitted on the fourth day of illness. He had a dirty, confluent membrane on the tonsils and palate and had massive glandular and periglandular edema of the neck (a "bull-neck"). T. was 40.0°C, pulse 126/min., respirations 28, blood pressure 115/70 mm.Hg, and heart sounds were normal. He was given 150,000 units of diphtheria antitoxin intravenously in one dose and was started on penicillin intramuscularly every three hours. Temperature returned to normal, and he seemed to be improving until the eighth day of disease when the pulse suddenly dropped to 50/min. and became very weak though regular. He was pale and listless. Heart sounds were of poor quality, and blood pressure was down to 68/38 mm.Hg. ECG taken at this time showed a 2:1 heart block. The next day his pulse was still very slow and at times irregular. Liver, not palpable on admission, was enlarged and tender. ECG showed complete AV dissociation (Figure 1A).

For the next few days he maintained a pulse rate between 40 and 50 and was gradually becoming more decompensated and going into peripheral collapse. On the 17th day of illness, he was discharged from the hospital at his parents' request. At home he was allowed to be up as much as he desired. He steadily grew worse. Three days after continued vomiting and generalized edema had appeared, he was returned to Sydenham Hospital. This was on the 27th day of illness. He was in congestive heart failure, with pitting edema of ankles, legs, sacrum, and abdomen, with ascites, a right-sided pleural effusion, and rales throughout both lungs. Heart was enlarged, sounds were quite distant, and there was a gallop rhythm. Liver was enlarged to the umbilicus. He could not raise his head nor swallow, and deep tendon reflexes were absent. Despite his poor condition, ECG taken on readmission revealed that his complete heart block had disappeared. He still had prolonged intraventricular conduction, however.

A thoracentesis was done, he was digitalized, placed in an oxygen tent, and fluids were given very slowly intravenously at first because of the inability to swallow. During the succeeding five days his edema disappeared. Two weeks later all signs of decompensation were gone, but his peripheral paralyses had become more extensive. There were paralyses of the external recti, the palate, diaphragm, intercostals, the muscles of the neck, and to a less extent the arms and legs. Treatment by tracheotomy and the use of the respirator were required before the pareses began to regress. From that time on his course was uneventful. Digitalis was discontinued after two months, and he was gradually allowed to get up. ECG remained stationary, though it continued to show abnormal T waves (Figure 1B). He was discharged on the 156th day of disease with a heart of normal size and with normal heart sounds.

Case 2. A. W. (33651), a 5-year-old white girl, was admitted on the second day of disease. She had tonsillar diphtheria and a "bullneck." T. was 38.1°C, pulse 116/min., respirations 24, blood pressure 100/80 mm.Hg. Heart sounds were clear and there was an apical systolic murmur. She
received 80,000 units of diphtheria antitoxin intravenously on admission. On the fifth day her pulse, which had been around 120/min. suddenly dropped to 70 and became irregular. Heart sounds were distant, and there was a muffled first sound at the mitral area in addition to the murmur there. ECG showed total AV dissociation, left bundle branch block, and low voltage (Figure 2A). Except for listlessness and slight pallor, the patient did not look particularly sick, despite the severity of the electrocardiographic changes.

Five and a half days later the pulse rose to 100/min. and remained there. ECG (Figure 2B) showed the return of normal sinus rhythm but a persistent left bundle branch block. Three weeks later intraventricular conduction time was normal too, but the ECG showed inverted T waves and low voltage indicating there was still some myocardial damage.

ECG did not return to normal for three months. Heart sounds slowly but progressively improved; the systolic murmur remained unchanged. During hospital stay she developed and recovered from palatal paralysis and extraocular muscle palsy as well as paralysis of accommodation. She was discharged on the 153rd day of disease with a normal heart, except for the murmur which had been present on admission. Except for left axis deviation, the ECG on discharge (Fig. 2C) was normal.

Case 3. E. P. (33781), a 14-year-old white boy, came in late in the course of his illness—on the seventh day. He had a "bullneck" and old tonsillar membranes. T. was 38°C, pulse 100/min., respirations 20, and blood pressure 120/80 mm.Hg. Heart sounds were good, and ECG was entirely normal. He was given 100,000 units of diphtheria antitoxin intravenously on admission. On the 12th day his first heart sound at the mitral area was depressed, and the rhythm was irregular; the rate was about 70/min. ECG taken at this time showed complete heart block and left bundle branch block (Figure 3A). His condition remained the same until the 24th day of illness (11 days after onset of the heart block). He vomited several times and complained of right upper quadrant pain. On examination, he had a marked waxen pallor and was apprehensive yet lethargic. Heart was enlarged; the sounds were poor; and a systolic murmur was present. The blood pressure dropped to 80/50 mm.Hg and remained low. The liver was enlarged to 4 cm below the costal margin and was tender.

He was placed in an oxygen tent, digitalized, and given plasma and glucose alternately intravenously very slowly for two days. Blood pressure came up to 95/70 mm.Hg and stabilized; his heart and liver became smaller. ECG then showed a nodal rhythm and persistent left bundle branch block (Figure 3B). By the 35th day he was much improved: heart sounds were good, the murmur was gone, and normal sinus rhythm had returned according to ECG. It was three more weeks before intraventricular conduction was normal. During convalescence he developed extensive
FIG. 3A. E. P., 12th day after onset. Complete AV block and left bundle branch block. Auricular rate 110/min., ventricular rate 90/min., QRS 0.12 sec. Auricles and ventricles beating irregularly, probably indicating severe degree of damage.

FIG. 3B. E. P., 27th day of illness. Nodal rhythm with retrograde conduction and left bundle branch block. Rate 72/min., QRS 0.12 sec.

FIG. 3C. E. P., 107th day. Left axis deviation only. Rate 100/min., PR 0.13 sec., QRS 0.06 sec.
peripheral paralyses, but by the 117th day he was ready for discharge and showed no residua from his myocarditis or pareses. ECG on discharge showed a left axis deviation but was otherwise normal (Figure 3C).

Case 4. J. G. (34080), a 7-year-old white boy was admitted on the first day of sickness with a very early membrane on his tonsils. T. was 39.8°C, pulse 130/min., respirations 20, blood pressure 114/72 mm.Hg. Heart sounds and ECG were normal on admission. He received 80,000 units of diphtheria antitoxin intravenously and experienced a febrile reaction a few hours later. He was given penicillin for the first few days. His course was not remarkable until the 15th day, when concomitant with the development of serum sickness the first heart sound became distant and pulse irregular. ECG revealed the presence of a 3:2 AV block with Wenckebach periods. The next
day there was no real change in his physical findings, but an ECG showed a complete heart block (Figure 4A). The following day there was again an incomplete block with Wenckebach periods (Figure 4B). Twenty-four hours later there was a first degree heart block. He maintained a prolonged PR interval (0.24 seconds) till the 36th day. The poor heart sounds and a systolic murmur were heard almost to the time of discharge on the 70th day of illness. ECG for the last three weeks of his hospital stay was normal (Figure 4C).

Case 5. H. H. (34827), a 31-year-old woman, was admitted in the third week of illness. For this reason it is impossible to date exactly the onset of myocarditis, but from her history it seems likely that it was present at least from the second week. Nineteen days before coming to Sydenham Hospital she developed a sore throat, fever, cough, and swollen glands in her neck. She was told she had an "ulcer of the throat." No treatment was given. Three days later her neck, which had been tremendously enlarged and was almost certainly a "bullneck" by description, began to diminish in size, but she began to have trouble breathing and was aphonic. Three days after the onset of labored breathing, she coughed up some pieces of membrane, and the day after, she coughed up a cast of the trachea and bronchi. This procedure was followed by immediate relief of her respiratory distress. The aphonia persisted however. In the next few days she began to feel exceedingly weak, being unable to do anything but lie in bed. She was nauseated and vomited occasionally. (This probably marked the onset of myocarditis.) From the beginning of her illness to her admission to the hospital 19 days later, she lost 9 kg.

On admission her temperature was 37.2°C, pulse 100/min., respirations 20, and blood pressure 104/70 mm.Hg. Heart sounds did not seem abnormal though they were a little soft. ECG showed left axis deviation and inverted T waves and depressed ST segments in leads I and II indicative of myocardial damage. Laryngoscopy revealed a healing ulcerative lesion. A few days later her voice began returning. On the 34th day there was a rapid pulse and a diminution of the first heart sound. ECG showed AV dissociation (Figure 5A). After three days she again had a sinus rhythm and a normal pulse rate. The patient's myocarditis continued to improve. After the 47th day her ECG remained normal except for the left axis deviation (Figure 5B).

She continued to develop other diphtheritic complications however. On the 50th day following onset of her illness she complained of blurred vision and was found to have paralysis of accommodation. This cleared after three weeks. On the 59th day a right facial paralysis appeared. Five days later her right arm became weak, and the day following she developed a left facial palsy as well. From that point on her course was one of gradual improvement. She went home on the 70th day of disease to be followed by her local physician. Her paralyses were better on discharge but had not completely disappeared.
Fig. 5A. H. H., 34th day after onset. Complete AV dissociation with auricular flutter. Auricular rate 350/min., and ventricular rate 145 to 175/min. Left axis deviation.

Fig. 5B. H. H., 49th day of illness. Left axis deviation. Rate is 94/min., PR 0.16 sec. and QRS 0.08 sec.
Fig. 6A. R. R., 9th day after onset. Complete AV dissociation and left bundle branch block. Auricular rate 110/min., ventricular rate 84/min., and QRS 0.11 sec.

Fig. 6B. R. R., 10th day of disease. Complete heart block. Auricular rate 80/min. Ventricular rate 77/min. Intraventricular conduction normal. QRS 0.04 sec.
Case 6. R. R. (34746), a 10-year-old white boy, was admitted on the third day of his sickness. T. was 39.1°C, pulse 104/min., respirations 24, and blood pressure 104/65 mm.Hg. He had diphtheritic membranes in the nose and covering the palate, tonsils, and pharynx, and he had a 'bullneck.' His heart sounds were not remarkable. He had been given 100,000 units of diphtheria antitoxin by the family physician the day before admission. He was given penicillin intramuscularly every three hours.

ECG taken on admission was perfectly normal. On the eighth day the first heart sound at the apex was suppressed and became more muffled the day following. ECG taken then showed complete AV dissociation and a left bundle branch block (Figure 6A). His blood pressure was somewhat lower, ranging from 85/60 to 78/40 mm.Hg, and his circulation time was prolonged. He was digitalized. On the 10th day ECG revealed the disappearance of the bundle branch block but again showed complete heart block (Figure 6B). The following day this too had gone. On the 12th day a systolic murmur was heard for the first time at the mitral area. His heart sounds did not improve until the 25th day of disease. His circulation time returned to normal as his myocarditis improved. Digitalis was discontinued on the 30th day of disease, and the next week he was allowed out of bed gradually. He was discharged on the 49th day with a heart that was normal on physical examination and with a normal ECG (Figure 6C).

**Discussion**

Probably the explanation for the recovery of these six patients lies in the balance between damage to the conduction system on one hand and to the myocardium as a whole on the other. Warthin,22 Marvin,23 and others6,24 have pointed out that pathologically there has been found no evidence of selective damage to the conduction system. It is conceivable, however, that focal areas of necrosis might be strategically situated so as to interfere with conduction yet leave enough "cardiac reserve" of normally functioning musculature to sustain life during the period of injury and repair. The normal
myocardial fibres probably hypertrophy later to take over the work for the damaged and scarred myocardium.

In view of the hypothesis of strategically located damage to the heart, it is of interest that two of these patients did not look nor feel particularly ill during the time when their conduction disturbances were so severe (Cases 2 and 4). From physical examination alone one would have suspected only a mild or moderate degree of cardiac damage.

Without an electrocardiogram it is quite possible that the complete heart block in some of these patients would have been missed. Not only was the physical appearance deceptively good in two of the patients but the pulse rate was at a normal level in four of the group (Cases 2, 3, 4, and 6) and elevated in one (Case 5). In only one patient (Case 1) was the pulse rate 50/min. or lower.

The use of digitalis in the presence of diphtheritic myocarditis and of a conduction disturbance as well is worthy of comment. It has been the impression of many observers that digitalis is contraindicated in this combination of circumstances and, if not directly harmful, that it is at best valueless. In contrast to this view we found prompt and definite improvement following digitalization in the cases of D. T. and E. P., both of whom were in congestive failure. In the case of R. R. its benefit was less dramatic; however, it was certainly not harmful even in the presence of AV dissociation. After observing the improvement following digitalization in Cases 1 and 3, we have extended its use to many other patients with moderate or severe myocardial damage and have observed untoward effects in none.

**SUMMARY**

Six patients who recovered from complete heart block in diphtheria have been reported. Four of these had intraventricular conduction disturbances as well. All but one of these patients had massive glandular and periglandular edema of the neck: a "bullneck." The shortest duration of the conduction disorders was two days. The longest was six weeks.

Two of the patients who recovered showed evidence of both cardiac decompensation and peripheral vascular collapse. Three of the patients were digitalized without untoward effect and with prompt improvement in at least two of them. Four of the six patients developed peripheral paralyses during convalescence.

**REFERENCES**


**Spanish Abstract**

**Restablecimiento del Bloque Completo del Corazón en la Difteria**

Se reportan seis restablecimientos entre 13 pacientes con bloque completo del corazón durante el curso de difteria. Cuatro de los que vivieron también tuvieron desordenes de conducción intraventricular. Estos cambios ocurrieron en pacientes con difteria severa. Cinco de los que se restablecieron tenían, cuando fueron admitidos, una formación de membrana extensiva y edema glandular y periglandular del cuello. Con la excepción de un paciente que se admitió a la tercera semana de la enfermedad, todos recibieron una dosis grande de antitoxina de difteria al llegar al Hospital Sydenham. Durante la convalescencia, cuatro de los que se restablecieron desarrollaron parésia de nervios periféricos múltiple.

El comienzo de la miocarditis tuvo lugar antes de la tercera semana de enfermedad. La duración de los desordenes de conducción fue de tres a 60 días. Puede ser que sin un electrocardiograma la disociación AV total en algunos casos haya sido olvidada, pues el pulso en cinco no era anormalmente despacio, y el exámen físico en dos reveló solamente ligeros cambios fuera de proporción a la severidad de los descubrimientos electrocardiográficos. Por otra parte, dos de los que se restablecieron mostraron señal tanto de enfermedad del corazón congestiva como de postración vascular periférica. La digitalización se mejoró pronto.
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NEWS AND ANNOUNCEMENTS

The Metropolitan Life Insurance Company of New York, through Dr. George M. Wheatley, 3rd Vice-president in charge of Health and Welfare Services, has made possible distribution of reprints from the Company’s "Statistical Bulletin" of memoranda of pediatric interest. The information is assembled from many sources and is not available in that form anywhere else. Fellows of the Academy will receive copies from the office of the Secretary. Copies also are available by writing to the Company, The Metropolitan Life Insurance Company, 1 Madison Avenue, New York City 10, N.Y., as long as the supply lasts. A recent publication of unusual interest is "Cancer Among Children," January 1949, Volume 3, No. 1.

* * *

Dr. James H. McKee, pediatrician and former Army flight Surgeon, died March 24, at the age of 78.

In 1918 Dr. McKee was one of the first to fly from coast to coast, making the flight with an Army squadron commanded by Gen. H. H. Arnold, former chief of the Air Forces, who then was Colonel Arnold. During the first World War Dr. McKee served as a major in the medical corps.

An alumnus of the Medical School of the University of Pennsylvania, he received a certificate from the Pennsylvania Medical Society in 1943 in recognition of his 50 years of service in his profession.

* * *

Dr. Rustin McIntosh, New York City, has been made chairman of the Council on Rheumatic Fever of the American Heart Association for 1949. He succeeds Dr. Harold M. Marvin.

* * *

St. Francis Sanatorium for Cardiac Children, Roslyn, L.I., N.Y., announces a Comprehensive Postgraduate Course in Rheumatic Fever and Rheumatic Heart Disease, at the Sanatorium, June 1 to June 14, 1949 (inclusive). Fee for course, $75.

This course is designed to give intensive training in the diagnosis and treatment of rheumatic fever and rheumatic heart disease.

For further information, address Rev. Mother Superior, F.M.M., Supt., St. Francis Sanatorium for Cardiac Children, Roslyn, L.I., N.Y.

* * *

Memorial Hospital Center for Cancer and Allied Diseases, New York, N.Y. has established a residency in Pediatrics.

The period of service is for a minimum of 6 months and its purpose is to train the pediatrician in the diagnosis and management of neoplastic diseases in childhood. The resident will also participate in the research program in progress at the Sloan-Kettering Institute. Three months’ credit toward pediatric residency training requirements has been approved by the American Board of Pediatrics.

For further particulars applicants may communicate with the Director, Pediatric Service, Memorial Hospital Center for Cancer and Allied Diseases, 444 East 68th Street, New York 21, N.Y.

ERRATUM

In the December 1948 issue, volume 2, number 6, page 703, the first line of the third paragraph should read: "The clinical results from the other agents were unsatisfactory in that no cures or satisfactory remissions were observed," instead of "The clinical results from the other agents were satisfactory in that no cures or satisfactory remissions were observed."

In the February 1948 issue, volume 3, number 2, page 275, line 28 should read: "One to two drops of 1:10,000 solution of atropine, 0.01 to 0.02 mg./kg., represents the smallest effective dose," instead of "One to two drops of a 1:10,000 solution of atropine, 0.01 to 0.22 mg./kg., represents the smallest effective dose."

In the February 1949 issue, volume 3, number 2, on page 226 the electrocardiogram in Figure 3B is printed incorrectly. Lead I is printed upside down as Lead III; Lead II is printed upside down; Lead III is printed right side up as Lead I.

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The online version of this article, along with updated information and services, is located on the World Wide Web at:
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An erratum has been published regarding this article. Please see the attached page for:
http://pediatrics.aappublications.org/content/3/5/731.4.full.pdf