Pathology of the Cardiac Conduction System in a Case of Diphtheria Associated with Atrial Arrhythmias and Heart Block

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Heart block is one of the well-known features of diphtheria, which is now an uncommon disease in modern civilization. Atrial arrhythmias also occur during diphtheria but are much less common than heart block. Although there are numerous excellent reviews concerning the heart in diphtheria,1-12 there have been relatively few studies of the pathology of the cardiac conduction system.

The recent death of a child with diphtheria afforded us the opportunity to study the cardiac conduction system at necropsy. During her terminal illness she developed both atrial arrhythmias and heart block.

Case Report

This 2½-year-old white girl was noted to be listless, anorexic, and febrile (101 F.) 2 days prior to admission. The following day she developed a cough, was more irritable, and complained of a sore throat. She was given intramuscular penicillin and an oral "mycin" drug. On March 25, 1962, the day of admission, she coughed up blood three times, and her temperature had risen to 103 F. She had lost 2 pounds during this acute illness.

On physical examination she appeared moderately ill and was breathing 50 times a minute. Temperature was 103 F., pulse rate 180, and blood pressure 120/80. The left tympanic membrane appeared dull, and the right membrane showed a decrease of the normal landmarks. The throat was injected, and the tonsils were enlarged and covered with a white exudate that did not extend beyond the tonsils. Bilateral cervical lymph nodes were palpable. Examination of the lungs revealed dullness, decreased breath sounds, and a few moist rales at the left base. Bilateral intercostal retraction without splinting was noted posteriorly. A grade-I systolic murmur was heard over the cardiac apex, but the heart was not enlarged.

The patient's laboratory studies revealed a hemoglobin of 12.2 Gm. per cent and white blood-cell count of 12,800 with 12 per cent polymorphonuclear leukocytes and 88 per cent lymphocytes. The cells appeared normal. Urinalysis was normal on two occasions, except for 10 to 20 leukocytes per high-power field. Tracheotomy was performed on the second hospital day. On the third hospital day Corynebacterium diphtheriae mitis was grown on Loeffler and Tellurite media. Throat cultures of the mother and three children were negative for C. diphtheriae.

Chest x-ray revealed pneumonitis involving the right upper lobe and left lower lobe on admission. This began to clear by the seventh day after admission.

Penicillin was begun, and 24 hours later tracheotomy became necessary. No membrane was noted on the vocal cords or in the trachea. On March 30 the heart rate dropped from 130 to 60, and an electrocardiogram revealed right bundle-branch block and 2:1 atrioventricular block (fig. 1). The patient was digitalized and given 50,000 units of diphtheria antitoxin intravenously. Despite these measures, the patient became worse, and atrial tachycardia, atrial flutter, and occasional runs of atrial fibrillation occurred (fig. 2). Finally, on April 2, there was no evidence of atrial activity (fig. 3). She died on April 3.

At necropsy C. diphtheriae was cultured from lung and tracheotomy site. Pseudomembranous tonsillitis and chronic laryngotracheo-bronchitis were noted. Fibrinous pneumonia was present in the left lower and right upper lobes. Pulmonary edema, congestion, and bilateral pleural effusion were noted. The liver showed fatty change, and there were asectes.

The heart weighed 48 Gm., and appeared slightly dilated but not hypertrophied; there was no predominant chamber. Ecchymoses were present throughout the myocardium of all four chambers. The major coronary arteries, the cardiac valves, and the intracardiac septa were normal.

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Figure 1
This first tracing taken 7 days after the onset of the illness shows both blocked and conducted atrial beats. In addition occasional inverted P waves after the QRS complexes suggest AV nodal rhythm with retrograde conduction. There is an intraventricular conduction defect resembling right branch block, but with loss of the initial R wave in V1. Changes in the T waves and RS-T junction are partly secondary to the conduction defect but suggest additional myocardial damage as well.

Figure 2
This tracing shows atrial tachycardia with block but is otherwise similar to figure 1.
Subserial sections of the sinus and atrioventricular nodes were prepared in a manner described previously.\textsuperscript{13, 14}

In the sinus node there were foci of vacuolization of fibers as well as acute inflammation (figs. 4 and 5). The process was identical to the myocarditis involving the rest of the heart. Near the sinus node many parasympathetic ganglia were the site of hemorrhage (fig. 6) and of vacuolization (fig. 7).

The histopathology of the atrioventricular node (fig. 8) and atrioventricular bundle (figs. 9 and 10) was similar to that of the sinus node.

**Discussion**

Correlation of the clinical and pathologic findings in this patient is apparent and requires little discussion. The morphologic changes in the conduction system are precisely the type to be anticipated as part of the generalized myocarditis, though their actual demonstration has been infrequent. It has perhaps been insufficiently emphasized that the neuropathology of diphtheria, which is familiar, includes the innervation of the

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*Figure 3*

*This tracing taken later the same day as figure 2 shows loss of all atrial activity.*
Vacuolar degeneration of fibers in the sinus node is shown, particularly in the upper portion of the photomicrograph. All the tissue shown is sinus node. This and all other illustrated sections are stained with the Goldner trichrome. × 192.

Hemorrhage and partial lysis in a ganglion adjacent to the sinus node, in the same section shown in figure 4. Two ganglion cells can be seen near the middle of the photomicrograph. × 480.

Hemorrhage and extensive liquefaction necrosis of the sinus node in a section made 4 mm. from the one in figure 4. Right atrial myocardium is seen in the lower left corner; all the other tissue is sinus node. × 192.

Large vacuoles within another juxtanodal ganglion 2 mm. anterior to the section in figure 1. × 480.

A high-power photomicrograph of the AV node. Striated fibers of the node appear near the middle of the right margin and terminate in vacuolar degeneration and hemorrhage. All the tissue here is AV node. × 480.

heart. Disease of the cardiac nerves and ganglia may well contribute to the development of both arrhythmias and heart block in diphtheria.

Summary

The histopathology of the sinus node, the atrioventricular node, and the atrioventricular bundle of the heart from a child dying of diphtheria is presented. The terminal illness included atrial arrhythmias and heart block.
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Figure 9
A low-power photomicrograph of the anterior margin of the AV bundle, as it begins to divide. Some congestion is apparent. × 75.

Figure 10
Vacuolar degeneration of fibers in the AV bundle. The channel crossing the center is a small vein. × 480.

The possible importance of the neuropathology of the diphtheritic heart is indicated.

References
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