TACHYCARDIA is sometimes a vexing problem to treat in infants and young children. Although most paroxysmal tachycardias at this age eventually respond to some form of therapy and with increasing age tend to wane and then disappear, the arrhythmias occasionally become intractable and may be responsible for sudden death. Because these cases are not usually fatal, there have been few clinicopathological studies from which to learn more about the underlying mechanisms of the problem. We have recently had the opportunity to study a fatal case and here wish to report some unusual abnormalities in the cardiac conduction system.

Case Report

A baby boy was first seen at the age of three months because of tachycardia. One cousin of this child has an identical form of tachycardia. Although the rate varied, it was usually so rapid that there was chronic cardiac failure and cardiac enlargement. No other cause for either the failure or cardiac enlargement was found. The tachycardia was regular and usually at a rate of about 240 beats/min. The QRS complexes were always narrow and at no time was a delta wave present. Special recordings demonstrated retrograde atrioventricular (A-V) block with an independent slower (about 130 beats/min) atrial rate (fig. 1). Since a His bundle complex was present just before every narrow QRS, the site of origin for the tachycardia must have been in the region of the His bundle. During many separate observations there was only one occasion when the sinus impulse may have been conducted to the ventricles, but at all other times atrial and ventricular activity were completely dissociated. That one occasion was marked by a few sinus captures and some Wenckebach periods at a time when the heart rate was temporarily slowed to about 110 beats/min after the administration of multiple drugs; at no time was there sustained or stable A-V conduction.

No treatment was successful in this patient, except to slow the tachycardia briefly. Measures employed included electrical countershock, and at various times the administration alone or in combination of the following medications: digitalis, diphenylhydantoin sodium, disopyramide, verapamil, procainamide, quinidine, ajmaline, propranolol, and pindolol. He died of uncontrolled cardiac failure at the age of one year.

At postmortem examination the only pertinent findings except for changes due to congestive failure were in the heart. The heart was generally enlarged but its examination was otherwise unremarkable except as will be noted below. The ventricular myocardium was entirely normal in histological appearance, and there was specifically no evidence of myocarditis or focal degeneration of any nature. No abnormalities were present in the sinus node, the A-V node, or the right or left bundle branches. The region of the A-V node and His bundle was serially sectioned. In its midpoint the His bundle was dispersed into a few tenuous irregularly shaped strands (figs. 2–7). The longitudinally oriented strands contained a mixture of normal or viable appearing cells as well as many in varying states of obvious degeneration (figs. 3, 4, 6, and 7). A few of the strands extended from the A-V node to the distal His bundle. Although the proximal portion of the His bundle was unremarkable, the distal part where bundle branches were originating did contain some excessive fibrosis (figs. 8 and 9).

Discussion

From the clinical and histopathological evidence it seems likely that this tachycardia originated in or near the His bundle. While we believe that a re-entrant mechanism utilizing the several separate longitudinally oriented strands is the
FIGURE 1 These three polygraphs recorded at different paper speeds demonstrate the nature of the tachycardia in our case. Bipolar and unipolar limb leads are simultaneously recorded with an intracardiac electrogram (EG) which is from the right atrium in panel A and from the region of the His bundle in panels B and C. Examples of P waves, QRS complexes (R), and His bundle complexes (H) are marked.

FIGURE 2 Photomicrograph of the proximal part of the His bundle (arrows). Interatrial septum (IAS) is above and interventricular septum (IVS) below; CFB is central fibrous body. Magnification in each picture is indicated with a reference bar. All sections were prepared with the Goldner trichrome stain. Higher magnifications from this section are shown in figures 3 and 4, that in figure 4 being encircled here.

FIGURE 3 At these higher magnifications of the section in figure 2 there is some dispersion of His bundle tissue within collagen and a small amount of cellular degeneration.

most likely electrophysiological basis for the tachycardia, we cannot exclude the possibility of an automatic focus in one or another component of this fragmented His bundle.

What is still less clear but perhaps more intriguing is the pathogenesis of the histological abnormality in the His bundle. In the human fetus the distal part of the A-V node and much of the His bundle tissue is normally rather widely dispersed within the central fibrous body.1,2 Beginning shortly after birth, these dispersed fragments progressively disappear until the adult configuration of the His bundle more nearly resembles a smoothly outlined cylinder with very few irregularities on its surface. Although it has been suggested that this tidying-up process in the postnatal and childhood period represents a normal molding and shaping of these crucial structures in the heart,1,2 the exact biochemical and cytological mechanisms are unknown. Available evidence suggests that different components of these frayed strands and stray pieces undergo degeneration and are resorbed during the time when the central fibrous body surrounding them is simultaneously undergoing its normal transformation.
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More details of the encircled section from figure 2 are shown here at two magnifications, illustrating the degenerative process in this strand of His bundle tissue.

From loosely organized young fibroblasts into the dense and compact collagen structure characteristic of the adult heart.

There is no question that many foci in the His bundle strands of the present case were undergoing degeneration. The degeneration had no associated inflammation of a nature suggesting infection. Nor was there any evidence that the degenerative foci were attributable to focal ischemia either due to local arterial narrowing lesions or due to a generalized hypoxic state; for example, if the latter were the case, there should have been commensurate foci of degeneration within other areas of the myocardium and there were not. Since the clinical problem was a prolonged one and since the localized degeneration of the His bundle was focal in distribution and was in various states of completion,

Near its midpoint the His bundle (arrows) was dispersed into several separate small strands of fibers. This section is about 100 microns anterior to that in figures 2-4.

This higher magnification of the section shown in figure 5 contains three groups of His bundle fibers in which some cells contain large vacuoles and are in the process of degeneration.
we visualize the process in this case as a dynamic or continuing one with probable periods of exacerbation and temporary remission.

The fact that our patient has a relative with the same clinical problem of severe tachycardia suggests a familial or hereditary fault. Other examples of faulty development of the central portion of the His bundle have been described which may have some relevance to the present case. Unexplained degeneration of the conduction system as described by Lenegre is now recognized to have a familial incidence, although the time of onset of this degeneration and its rate of progression may vary widely. That type of problem is often associated with varying degrees of A-V block, but it is not localized to the His bundle as in the present case. Another abnormality recently described in purebred Pug dogs is a hereditary stenosis of the His bundle in its midportion. Although the site of involvement in the Pug dogs is exactly the same as in the heart of the present case, the stenotic process in the dogs is one of nearly symmetrical narrowing, rather than the frayed separate linear strands seen in our case (fig. 10). Furthermore, no recent degenerative foci were observed in the dogs although they may have occurred at some stage of development which was not investigated. The difference in the histological abnormality, even though both were found in the midportion of the His bundle, may be attributable to a species difference between human and canine developmental processes.

Dispersion of the linearly disposed fragments of His bundle in the present case superficially resembled normal fetal dispersion of the His bundle but differed from it in two important ways: there were far fewer and smaller strands than are normally present in the human fetal His bundle, and...
there were numerous foci of degeneration which are not normally seen in the fetal His bundle. Focal degeneration of margins of the human His bundle is observed in the postnatal period, however, and its episodic nature and its presence within a vitally necessary structure in the heart have led to the suggestion that electrical instability may be an important contributing factor in the pathogenesis of crib death and other unexplained sudden deaths of babies.6

Far more of the His bundle was destroyed in the present case, however, than is seen in most hearts from the postnatal period. Furthermore, the normal postnatal resorption of the His bundle is almost exclusively on its left side, whereas the process in the present case involved the entire cross-sectional area of the His bundle. These differences may be because the process in the present case is of a nature different from the normal postnatal molding and shaping of A-V node and His bundle. However, it may also be because electrical instability of the heart in this child was clinically recognized and heroic efforts at treatment permitted him to survive long enough so that more extensive changes developed. If the latter suspicion is true, it still does not explain why most normal human infants survive to adulthood with smoothly outlined undestroyed His bundles. The crucial difference may be that in the present case a normal postnatal process became abnormal by being unchecked. It is the exact nature of what turns the process on and at just the appropriate time also turns it off which remains unexplained, but one may logically suspect some genetically controlled reaction at the interface region between cells of the His bundle and young fibroblasts of the central fibrous body.

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