

Todd fibres—Purkinje fibres—in the wall of the right atrium in dolphins (Their structure and hypothetical function)

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Summary

Todd fibres—Purkinje fibre-like structures—have been observed in the right atrial wall of the dolphin heart. Their main characteristic is the intercalation between the ordinary atrial muscle fibres, a striking difference with the Purkinje fibres. Their function may be an increase of the propagation of the stimulus aroused in the sinu-atrial node to the atrioventricular node, resulting in bradycardia during diving.

Introduction

The bradycardial reflex in aquatic mammals during diving has to be a real fast one. The stimulus aroused in the sensitive peripheral organs of the trigeminal nerve reaches the vagal centre arousing there vagal stimuli, which reach the parasympathetic ganglia in the vicinity of the sinuatrial node—the pacemaker. The activated node sends its stimuli via the ordinary atrial muscle fibres to the atrioventricular node. The last one regulates the decreased frequency of the heartbeat. A fast conduction of the stimuli from the sinuatrial node to the atrioventricular node is necessary for an adequate functioning of the heart during diving (bradycardia). The discussions about special pathways between these nodes have been referred by Copenhaver & Truex, 1952; James, 1963; ter Borg, 1948–49 and Qayyum, 1974. There is a general opinion today, that the special pathways don't exist. Nevertheless Purkinje fibres like structures have been observed in the wall of the right atrium (v.d. Stricht & Todd, 1919; Todd, 1932 and ter Borg, 1948–49). The function of these structures remains unknown.

The aim of this communication is to report about the finding of fibres similar to Purkinje fibres—named Todd fibres—in the wall of the right atrium in the dolphin heart and to formulate an hypothesis about their function in these animals.

Material and techniques

Samples of the wall of the right atrium in the vicinity of the sinuatrial node taken from the hearts of two

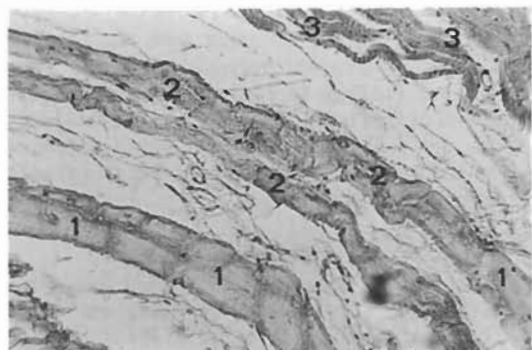


Figure 1. 1, Purkinje fibres; 2, transitional fibres; 3, ordinary ventricular muscle fibres processed according to Van Gieson microscopical magnification $\times 120$.

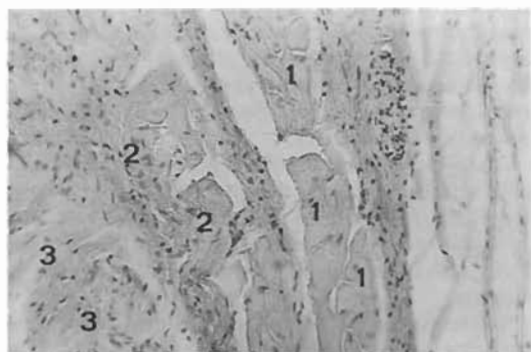


Figure 2. 1, Todd fibres; 2, transitional fibres; 3, ordinary atrial muscle fibres processed according to Van Gieson microscopical magnification $\times 120$.

dolphins (*Lagenorhynchus albirostris*, Gray, 1846) have been fixed in 4% formaldehyde. The samples were cut longitudinally in slices of 10μ thick. The slices were processed according to van Gieson.

Results

Fibres (Todd fibres, Fig. 2) similar to Purkinje fibres (Fig. 1) have been observed in the wall of the right

atrium direct beneath the pericardium. The most characteristic histological features of these fibres are: The size of the diameter 5 to 10 times larger than those of ordinary atrial wall muscle fibres; the nucleus is round and large, sometimes balloon shaped and is localized in the centre of the fibres. More than one nucleus may be observed in one fibre. Some fibres display a faint transverse striation. They are surrounded by a loose connective tissue sheath, in which some nerve fibres are present. Observations made in serial slices give evidence for an intercalation of the Todd fibres between the ordinary atrial wall muscle fibres. A direct contact between the Todd fibres and the sinuatrial node fibres has not been found.

The most striking difference with the Purkinje fibres is the mentioned intercalation of the Todd fibres, since Purkinje fibres are intercalated between the fibres of the conducting system and the ordinary ventricular wall muscle fibres. A minor difference is the less contrastful staining with the van Gieson technique in the Todd fibres.

Discussion

Todd fibres have been described in many land mammals (vide supra) and now too in aquatic mammals.

The papers from ter Borg (1948-49) and Dudan e.c. 1984-85) ask some special attention in this discussion. The first one describes Todd fibres in the right atrial wall of the horse rather extensively, but doesn't relate them with a possible function. The second presented a cardiovascular study about the function of the horse heart and wrote: 'Considering that in horses the high vagal tone is responsible for a physiological bradycardia, it seems possible, that the autonomous nervous system plays a role in the pathogenesis of myocardial scars so frequently observed in these species'.

The link between the Todd fibres and the bradycardia in horses seems acceptable. The fast change from bradycardia into tachycardia in horses—and reversed—is a question of life and death. The wild horse has to save its life by a really fast escape in danger.

So the diving dolphin has to change his heart rate in the cycles of emerging and diving very fast (v. Nie, 1986). The Todd fibres suit very well the autonomous nervous circuit active in the diving mammal.

Hypothetically the Todd fibres may diminish the propagation time of the stimulus aroused in the sinuatrial node on its way to the atrioventricular node markedly, since the propagation time in Purkinje

fibres is twice as fast as in ordinary heart muscle fibres, 0.6 ms^{-1} versus 0.3 ms^{-1} (Guyton, 1981).

Conclusion

Todd fibres—Purkinje fibre-like structures—occur in the right atrial wall of the dolphin heart. These fibres differ from Purkinje fibres in so far as they are intercalated between the ordinary atrial wall muscle fibres. Todd fibres have been observed in other mammals too.

Their hypothetical function in the dolphin may be the increase of the propagation time of the stimulus aroused in the sinuatrial node going to the atrioventricular node during the diving reflex.

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