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The sinuatrial node and its adjacent autonomous ganglia cells in aquatic mammals (A morphological approach)

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In a comparative investigation of the sinuatrial node and its vicinity in aquatic mammals and in non professional mammalian divers the great difference in the number of autonomous ganglia cells in the vicinity of the sinuatrial node was described. The computing of the results led to the conclusion, that this morphological approach of the sinuatrial node and its vicinity supports the physiological statement: The deep bradycardia during diving in aquatic mammals is caused by an overruling of the sinuatrial node activity through the influence of the parasympathetic part of the autonomous nervous system.

Introduction

In the general anatomical and physiological literature (Mitchell & Patterson 1967; Nie 1983) it is accepted, that the heart beat frequency is initiated through and under control of the (autonomous) conducting system of the heart, consisting of the sinuatrial node (pacemaker), the atrioventricular node, the common atrioventricular bundle and its branches. The system ends in the subendocardial plexus of specialized 'Purkinje' muscle fibres. The last ones conduct the stimulus aroused in the sinuatrial node from the atrioventricular node and its branches towards the ordinary heart muscle fibres.

It is generally accepted too (Munel J. F. 1982; Rushmer 1958), that this conducting system in special cases is overruled by both parts of the autonomic nervous system (orthosympathetic and parasympathetic). The orthosympathetic influence arouses an increase of the heart beat frequency, while the parasympathetic part results in a decrease of this frequency. The last ganglia cells before the target organ—the sinuatrial node—of the orthosympathetic part lie at some distance of the target organ in the sympathetic trunk, while those of the parasympathetic part lie in the direct environs of the target organ—sinuatrial node.

The deep bradycardia in aquatic mammals during diving is due to stimulation by the parasympathetic part (n. vagus) of the autonomous nervous system (Andersen 1966; Angell, Burg 1972).

Up till now a morphological approach of this physiological report is not available. One may expect by assumption on base of the present knowledge (vide supra), that in aquatic mammals a relatively great number of parasympathetic ganglia are present in the vicinity of the sinuatrial node.

To test this hypothesis a comparative quantitative morphological examination of the presence of ganglia cells in the vicinity of the sinuatrial node in professional and non professional divers will be presented in this paper.

Material and techniques

The sinuatrial node and its environs taken from the heart of two dolphins (*Lagenorhynchus albirostris*, Gray, 1846); four harbour porpoises (*Phocoena phocoena*, Linnaeus, 1758); four seals (*Pusa sibirica*, Gmelin, 1788) and three muskrats (*Ondatra zibethicus*, Linnaeus, 1766) have been fixed in 4% formaldehyde.

In most of the cases the samples were cut transversally. In one case in the dolphin and in three cases

Table 1 % Slices with sinuatrial node fibres and ganglia cells

Man (2–69)	30
Cattle (2–51)	13
Sheep (3–80)	40
Goat (1–62)	21
Dog (2–44)	27
Pig (2–71)	1.4
Aquatic Mammals	
Dolphin (1–230 tr.) (1–55 lo.)	90
Porpoise (1–75 tr.) (3–56 lo.)	92
Seal (4–94)	95
Muskrat (3–13)	90

Comment: The first figure between the brackets means the numbers of searched animals, the second figure indicates the total number of searched slices; tr. = transversal cut, lo. = longitudinal cut.

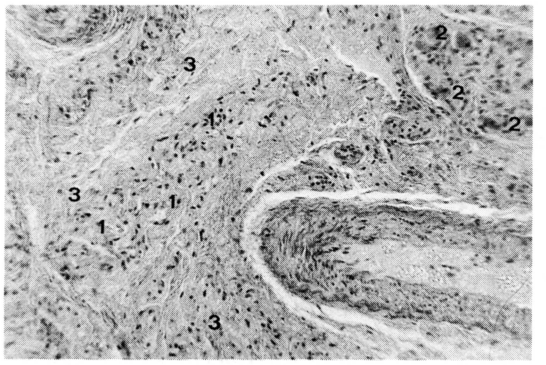

Fig. 1 Sinuatrial node fibres and adjacent autonomous ganglia cells in a harbour porpoise. Microscopical magnification 120 ×

1. Sinuatrial node fibres
2. Autonomous ganglia cells
3. Connective tissue

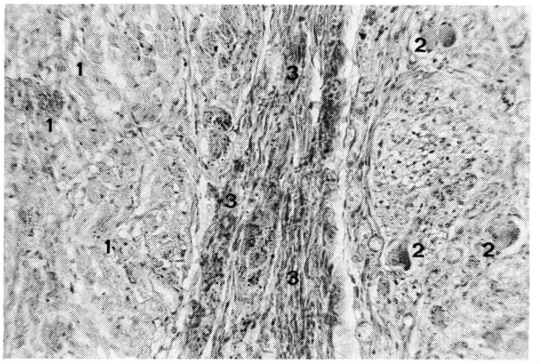

Fig. 2 Sinuatrial node fibres and adjacent autonomous ganglia cells in a common seal. Microscopical magnification 120 ×

1. Sinuatrial node fibres
2. Autonomous ganglia cells
3. Connective tissue

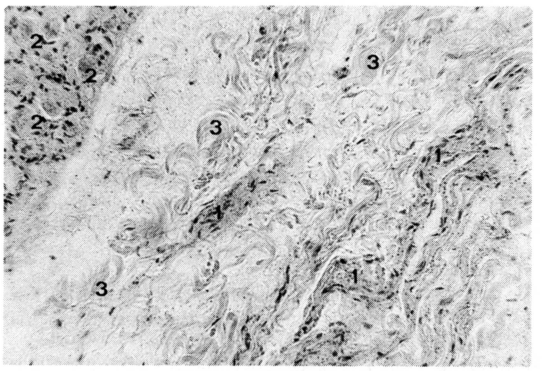

Fig. 3. Sinuatrial node fibres and adjacent autonomous ganglia cells in a muskrat. Microscopical magnification 120 ×

1. Sinuatrial node fibres
2. Autonomous ganglia cells
3. Connective tissue

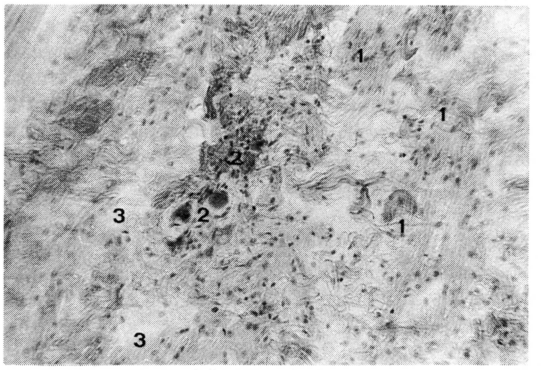

Fig. 4. Sinuatrial node fibres and adjacent automous ganglia cells in a pig. Microscopical magnification 120 ×

1. Sinuatrial node fibres
2. Autonomous ganglia cells
3. Connective tissue

in the harbour porpoises they have been cut longitudinally. The slices were 10 μ thick, every 10th slice has been searched microscopically. The slices were processed according to van Gieson.

The state of the samples taken from the hearts of the professional divers is not 'really fresh', all animals were dead for at least two days. So an electron microscopic and histochemic examination were not practicable.

For comparative purposes equal parts of the hearts from man, cattle, sheep, goat, dog and pig were examined too.

All slices were examined under a ×40 magnification for the presence of sinuatrial node fibres with or without adjacent ganglia cells. The results were computed quantitatively, so the number of ranges of vision in the group, sinuatrial node fibres with ganglia cells, is expressed as a percentage of total number of ranges with sinuatrial node fibres.

Results

The quantitative results are listed in Table 1. The pictures display a selection of the ranges of vision studied.

Comment

The histological pictures of the sinuatrial node and its vicinity from aquatic mammals, match with those

described in the literature (survey, Robb 1965; dolphin, Arpino 1934, Nie 1985; harbour porpoise, King & Coakley 1958 and common seal, Nie 1983). In all these cases the great number of ganglia cells in the vicinity of the sinuatrial node is striking.

The pictures of equal samples from the heart of non professional divers resemble those referred in the current literature (Kikuchi 1976; King & Coakley 1958). In these cases the number of ganglia cells is relatively low.

The results give a rather good evidence for the influence of the parasympathetic part of the autonomic nervous system on the sinuatrial node leading to a bradycardia during diving.

A contact between the fibres of the sinuatrial node and those of the ganglia cells could not be checked with the used histological technique however. In non professional divers this contact is reviewed and described by Kikuchi (1976), using electron microscopical techniques.

Conclusion

The great number of autonomous ganglia cells present in the vicinity of the sinuatrial node of aquatic mammals—detected by morphological technics—supports the physiological statement about the cause of the deep bradycardia in these mammals during diving.

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