Age-related reduction of the satellite cell sheath around spinal ganglion neurons in the rabbit

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Summary

The volumes of the nerve cell bodies and those of the enveloping satellite cell sheaths from spinal ganglia of young adult and aged rabbits were determined by morphometric methods using the electron microscope. The mean volume of the nerve cell bodies was greater in the old rabbits than in young adults; this is probably related to the larger body size of the old animals. The mean volume of the satellite cell sheaths was, however, smaller in the aged rabbits than in the young adults. Consequently the volume ratio between the satellite cell sheaths and the related nerve cell bodies was significantly smaller in the aged animals. Since satellite cells play an important role in the support of the neuron, the reduction in volume of the perineuronal sheath could be associated with a decrease in the trophic activity of satellite cells towards the enveloped neuron with consequences for neuronal activity. Furthermore, in the satellite cell sheaths of old rabbits, the number and extension of gaps that leave the neuronal surface directly exposed to the basal lamina were significantly increased. Since spinal ganglia lack a blood-nervous tissue barrier, only the satellite cell sheath controls the traffic of material to the nerve cell body. Because the neuronal surface unprotected by the satellite cell envelopment is significantly more extensive in the spinal ganglia of old rabbits than in those of young adults, the nerve cells of the former are more exposed to potential damage by harmful substances. A dense undercoating was seen very frequently beneath the portions of the neuronal plasma membrane not covered by satellite cells.

Introduction

Age-related changes in sensory ganglia have been the subject of many investigations. Most studies have focused on neurons with particular emphasis on the influence of age on the number (Hatai, 1902; Gardner, 1940; Emery & Singhal, 1973; Nagashima & Oota, 1974; Ohta et al., 1974; Kawamura & Dyck, 1978; Otte et al., 1978; Keithley & Feldman, 1979; Ball et al., 1982; Schmalbruch, 1987; Aldskogius & Risling, 1989; Keithley et al., 1989) and structure (Hodge, 1894; Truex, 1940; Andrew, 1941; Field, 1952; Hess, 1955; Kotani & Kawashima, 1961; Sosa & de Zorrilla, 1966; Scharf & Blumenthal, 1967; Glees & Gopinath, 1973; van den Bosch de Aguilar & Vanneste, 1981; Vanneste & van den Bosch de Aguilar, 1981, 1988; Koistinaho et al., 1991; Scaravilli et al., 1991; Fujisawa, 1992; Kishikawa et al., 1992) of sensory ganglion neurons. In contrast, changes to neuroglia in sensory ganglia during ageing have received little attention (Kotani & Kawashima, 1961; van den Bosch de Aguilar & Vanneste, 1983; Carney & Lyon, 1990) and the effects of ageing on the quantitative relations between glial and nervous tissue seem to have been neglected; this is somewhat surprising since nerve and glial cells carry out cooperative activities, so that alterations to neuroglia may lead to neuronal dysfunction. To fill this gap we have studied the quantitative relations between glial and nervous tissue in the spinal ganglia of young adult and aged rabbits. In these ganglia, it is well known that each nerve cell body is usually enveloped by its own satellite cell sheath thus constituting a unit which is separated by connective tissue from other units of the ganglion (Fig. 1). This particular organization makes it possible to study the quantitative relations between glial and nervous tissue in spinal ganglia at the level of the individual neuron, unlike the case in the CNS.

Materials and methods

Animals

Rabbits (Oryctolagus cuniculus) aged 12 months (two animals, one male and one female, 3.4–3.5 kg body weight) and 60–79 months (three animals, one male and two females, 4–4.2 kg

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Fig. 1. Unit consisting of a nerve cell body (N₁) and its enveloping satellite cell sheath (SC). This electron micrograph illustrates the type of preparation used in our quantitative evaluations. The nucleolus (nu) of the nerve cell body is evident; the satellite cell sheath belonging to this unit is sharply separated from those enveloping the adjacent nerve cell bodies (N₂-N₅) by the connective tissue space (ct). v, blood vessel. Spinal ganglion of a rabbit aged 12 months. ×4500.

body weight) were used. The dates of birth of these animals are well documented; all had been raised by a specialist rabbit breeder with particular attention to hygiene and regular veterinary inspections. Since the life span of the normal healthy Oryctolagus is 60–72 months (Harkness & Wagner, 1983) or 84–96 months (Weisbroth et al., 1974), the 12-month-old rabbits we studied were young adults and the 60–79-month-old animals were aged rabbits. Furthermore, the end of fertility is usually considered to mark the onset of senescence and female rabbits are not normally fertile after 60 months, so that the 60–79-month-old animals are to be considered aged from this point of view also.

Light and electron microscopy
The animals were perfused transcardially with a solution containing 2% formaldehyde and 2% glutaraldehyde in 0.1 M