Primary Afferent Projections to the Spinal Cord and the Dorsal Column Nuclear Complex in the Turtle Pseudemys

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Summary. Primary afferent projections from cervical and lumbar levels were studied in the turtle Pseudemys scripta elegans. Injections of radioactive amino acids, wheat germ agglutinin and horseradish peroxidase were made into the dorsal root ganglia or the spinal cord. Previous reports on the terminal distribution of primary afferents within the ipsilateral segment of entry were confirmed (Kusuma and ten Donkelaar 1979, 1980) and additional dorsal root projections were demonstrated to the contralateral side and to several neighboring spinal segments. The primary afferent projections to the brainstem were essentially restricted to a dorsolateral area that appears to be homologous to the main dorsal column nuclei (n. gracilis and n. cuneatus medialis) in mammals. While exhibiting a similarly extensive rostro-caudal span, the projections originating from lumbar injections terminated more medially, those from cervical injections more laterally. The labeling pattern suggested that terminations are mainly on dorsally extending dendrites.

Key words: Dorsal root projections – Spinal cord – Dorsal column nuclear complex – Vestibular complex – Turtle

Introduction

The dorsal column nuclei of mammals represent an essential region in relaying and modulating somatosensorimotor information. Receiving primary afferent projections (e.g. rat: Beck 1981; cat: Keller and Hand 1970; bush-baby: Albright and Haines 1978; monkey: Carpenter et al. 1968; Beckstead and Norgren 1979) and fibers from the somatosensorimotor cortex (Kuypers and Tuerk 1964; Weisberg and Rustioni 1979), the main group of dorsal column nuclei (n. gracilis and n. cuneatus medialis) is reciprocally connected
with the spinal cord (Burton and Loewy 1977; Rustioni and Kaufmann 1977) and possibly with the reticular formation (Odutuola 1977; Sotigu and Marin 1977; Salibi et al. 1980) and the red nucleus (Edwards 1972; Martin et al. 1974; Berkley and Hand 1978). Efferent connections terminate upon the thalamus (ventrobasal complex, posterior nuclear group and zona incerta), the pretectum, the deep layers of the superior colliculus, the intercollicular area, the nucleus z and the lateral cervical nucleus (Hazlett et al. 1972; Schroeder and Jane 1976; Berkley and Hand 1978; Boivie 1978; Feldman and Kruger 1980). There are direct projections to the cerebellar cortex (particularly from the accessory cuneate nucleus, but also from the main nuclei) and indirect ones via the inferior olive (Groenewegen et al. 1975; Berkley and Worden 1978; Kalil 1979; Somana and Walberg 1980; Gray et al. 1981).

Unfortunately, a comparison of this extensive pattern of connectivity in mammals with its counterpart in submammalian forms is not yet possible due to the paucity of information on the dorsal column nuclear connectivity in lower vertebrates. The dorsal column nuclear complex (DC) has been shown to receive primary afferent fibers in anurans and reptiles (Goldby and Robinson 1962; Joseph and Whitlock 1968a; Jacobs and Sis 1980; Antal et al. 1980; Kusuma and ten Donkelaar 1980) and telencephalic projections in birds (Zeier and Karten 1971; Karten et al. 1978). It has been shown to project to the cervical spinal cord in various reptiles (ten Donkelaar et al. 1980; Woodson and Künzle 1982) and may give rise to ascending projections to the intercollicular area, the tectum opticum and the ventrolateral thalamic nucleus in lizards (Ebbesson 1978).

A major drawback in studying the connectivity of DC in nonmammals lies in the fact that the medullary area presumed to represent the region homologous to the mammalian dorsal column nuclei is little differentiated cytoarchitecturally from adjacent regions (birds, crocodiles and lizards) if at all (snakes, turtles and anurans) in lower tetrapods (birds: Cohen and Karten 1974; reptiles: Schwab 1979; ten Donkelaar and Nieuwenhuys 1979; anurans: Neary and Wilczynski 1977; Antal et al. 1980) and possibly lacking in fish (Zeehandelaar 1921; but see Finger 1978). The present autoradiographic analysis of dorsal root projections in the turtle Pseudemys aims to determine more precisely the location and the extent of DC and thus lay a foundation for further studies of its afferent and efferent connectivity. Furthermore, data will be presented demonstrating that the terminal field of primary afferents within the spinal cord is not restricted to the ipsilateral segment of entry, a result that was not obtained with a recent degeneration study (Kusuma and ten Donkelaar 1980). Preliminary findings have been published (Künzle and Woodson 1981). There were also projections to the cerebellar cortex which have been dealt with separately (Künzle 1982).

Materials and Methods

17 turtles (Pseudemys scripta elegans) weighing between 350 and 800 g were used. The experiments were carried out under endotracheal anesthesia (1.5–2.5% halothane with a 2:1 oxygen-nitrogen mixture) with the aid of a Harvard rodent respirator. Injections of radioactive amino