Catecholamine varicosities in cat dorsal root ganglion and spinal ventral roots

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Catecholamine (CA) varicosities have been observed within the dorsal root ganglion and spinal ventral roots of the cat at all spinal levels. There was no apparent change in either appearance or numbers of these CA varicosities following spinal transection or distal spinal root lesion. It is suggested that the source of CA innervation of these areas is sympathetic accompanying transdural blood vessels.

Catecholamine fibers have been described at all spinal cord levels throughout the dorsal and ventral grey matter. The primary source of these catecholamine (CA) fibers has been shown to be suprasegmental brain stem nuclei. Catecholamine fibers have also been described within the ventral roots (VR) and dorsal root ganglia (DRG) as well as in cranial ganglia. Both suprasegmental and sympathetic sources of CA innervation to these areas have been suggested. The purpose of this investigation was to further study the types of CA varicosities in the DRG/VR region and their possible sources.

Cats weighing 2–2.5 kg were anesthetized with Nembutal (35 mg/kg). Following a spinal laminectomy dorsal root ganglia were removed and quickly frozen in a metal container cooled by a dry-ice-acetone mixture. Cryostat sections (6–8 μm) were collected onto clean slides and reacted for CA histofluorescence by a modification of the de la Torre and Surgeon technique as reported previously. Sections were viewed with a Zeiss Epifluor system equipped with a 405/435 nm filter combination for visualizing catecholamines. To locate the position of blood vessels, a 2% solution of the fluorescent dye, Evans Blue, was injected intravenously 10 min before sacrifice and the tissue was subsequently treated as described above for CA histofluorescence. Evans Blue was visualized with a 550/590 nm filter combination.

In non-lesioned animals, CA fibers with typical varicosities were observed in the DRG and VR areas at all spinal levels. Most CA varicosities within the DRG traversed the ganglion area within axon bundles. However, unlike those described in the rat, CA nerve fibers in the DRG of the cat were very often seen in close association with ganglion cell bodies suggestive of synaptic contact (Fig. 1). Fibers in transition between axon bundles and ganglion cell regions were commonly observed as were occasional CA fiber bifurcations.

Catecholamine fibers were also seen in the ventral roots. They were fewer in number than in the DRG and their course paralleled the course of ventral root axons. Only rarely were CA fibers seen in the dorsal roots.

The general morphology of the CA fibers in the DRG/VR area, as in the spinal grey matter, takes two forms. The first type (Fig. 2A) is a single, fine, varicose fiber which is the type most common in the spinal cord grey matter. Within the spinal cord, this form of CA fiber is eliminated by a rostral spinal transection indicating a suprasegmental source from brain stem nuclei. The second type (Fig. 2B) is an intertwined...
Fig. 1. Fluorescent catecholamine varicosities (arrows) within the dorsal root ganglion in close apposition to ganglion cell bodies which contain autofluorescent lipids (double arrowhead). Bar equals 10 μm.

bundle of several fine CA fibers which collectively produce intense fluorescence. Within the spinal cord this type of arrangement of CA fibers is generally associated with blood vessels and is presumed to be sympathetic in origin. Following a chronic spinal transection, CA fibers have been described within the spinal cord caudal to the transection, located primarily along the ventromedial fissure accompanying blood vessels. The majority of CA fibers in the DRG were of the second type.

To determine the source of the CA varicosities in the DRG and ventral roots, various lesions were performed two weeks prior to sacrifice (Fig. 4). Two weeks is ample time for complete degeneration of lesioned CA fibers. There are no CA containing cell bodies located within the spinal cord; therefore a rostral spinal transection is sufficient to eliminate all CA-containing fibers innervating the DRG/VR region which originate from central sources. Following a total transection of the spinal cord at the thoracic level, there was no visible change in the numbers of CA varicosities within the lumbar DRG and ventral roots, though the spinal grey matter was nearly devoid of all CA-containing fibers. In separate experiments, the ventral roots were lesioned proximal to the DRG and following a 3 week survival period, CA varicosities were observed not only in the DRG but also among the degeneration ventral root fibers. Since proximal lesions of spinal cord or of the VR did not produce a detectable change in the numbers of CA fibers in the DRG or ventral roots, supraspinal CA sources are presumed to contribute only minimally if at all to the CA fibers in this region. The other possible source of CA varicosities innervating the DRG is from the sympathetic system. When a chronic lesion was performed distal to the lumbar DRG again, CA varicosities of both types survived in the DRG and ventral roots. This indicated that peripheral nerves were not the primary means of access for sympathetic CA fibers innervating the DRG/VR region. Alternative means of access of these fibers to the DRG region is illustrated in Fig. 3. Catecholamine varicosities are seen entering the DRG accompanying blood vessels which vascularize this region transdurally. Transdural innervation is likely to be the primary source of CA varicosities in the DRG and ventral roots since neither distal nor proximal neural lesions greatly affect the number of CA fibers remaining there (Fig. 4).

To determine the extent to which CA varicosities are associated with DRG and VR blood vessels, intravascular injections of the fluorescent dye, Evans Blue, were made to label blood vessel locations. Within the spinal cord there was a dense pattern of labeled blood vessels throughout the grey matter. The spinal cord blood vessels were rarely seen adjacent to CA fibers and their course did not approximate the pattern of CA varicosities in the spinal cord. Within the spinal ventral root the course of both CA varicosities and Evans Blue-filled blood vessels paralleled the course of nerve fibers.
Fig. 2. Catecholamine (CA) varicosities in the dorsal root ganglion/ventral root region appear in two forms. A: the first type is a single, fine, varicose fiber. (Photograph from ventral root. Bar equals 10 µm.) B: the second type is an intertwined collection of several CA fibers. (Photograph from dorsal root ganglion. Bar equals 10 µm.) Note difference in magnification.

mity of CA fibers with blood vessels was often observed; however, numerous examples of non-association were also noted. In the DRG the relation of CA fibers to blood vessels could not be tested by the Evans Blue technique since there is no blood-brain barrier in the ganglion cell region. Extravasated Evans Blue filled the pericellular region making the localization of blood vessels impossible.

The DRG is highly vascularized and fine capillaries have been described as surrounding virtually every cell. Due to the close proximity of the CA fibers to both the ganglion cell bodies and the ganglionic vasculature, the relationship between these structures can only be resolved at the electron microscopic level.

These studies have demonstrated that there are large numbers of CA varicosities within the DRG and ventral roots of the cat and the primary means of access of these fibers to this region is

Fig. 3. Catecholamine fibers entering the dorsal root ganglion accompanying a blood vessel (BV). Bar equals 100 µm.
most likely transdural, accompanying entering blood vessels. It has not yet been determined to what degree CA-containing axons remain associated with blood vessels once within the DRG.

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