

Composition of the Cervical Sympathetic Trunk.*

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Introduction. The cervical sympathetic trunk has generally been regarded as being composed solely of myelinated preganglionic axons.¹ It has been shown recently by Foley and DuBois² that this view is no longer tenable; for, not only are many of the nerve fibers of the cervical sympathetic trunk of the cat, dog, and rat unmyelinated, but nerve fibers persist in the trunk of the cat after the preganglionic axons have been eliminated by sectioning the roots or removing the ganglia of the first nine thoracic spinal nerves. In this report, however, the authors recognized that the number of persistent axons which was reported should be accepted with reservations since regeneration might have contributed to some of them, a possibility favored by the rather long post-operative survival times employed in some cases. Accordingly, further experiments, in which the postoperative survival times were reduced, have been devised with the intention of confirming or revising the previous results.

Materials and Methods. The preganglionic axons were eliminated from the cervical sympathetic trunks of 13 cats by three methods: (a) section of the dorsal and ventral roots of the first 9 thoracic spinal nerves, (b) removal of the dorsal root ganglia of the first 9 thoracic spinal nerves, or (c) severance of the rami which pass to the stellate ganglion from the upper thoracic nerves and simultaneous removal of a segment of thoracic sympathetic trunk below the stellate ganglion.[†]

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¹ Billingsley, P. R., and Ranson, S. W., *J. Comp. Neur.*, 1918, **29**, 359.

² Foley, James O., and DuBois, F. S., *J. Comp. Neur.*, 1940, **72**, 587.

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In 5 animals the surgery was performed on the right side while in 8 others it was done on the left.

The time allotted for degeneration of the preganglionic nerve fibers in the cervical sympathetic trunk after both rhizotomy and ganglionectomy of the spinal nerves was 21 days or less. A period of 21 days is an adequate maximum interval for degeneration, there being no histological evidence of regenerating axons in the degenerated nerves of the animals which have been terminated at the end of this postoperative survival period. On the other hand, histological examination of the degenerate cervical sympathetic trunks of cats, in which the preganglionic axons have been eliminated by combined sympathectomy and section of the rami of the stellate ganglion, has shown that regeneration often occurs if the animals are allowed to live as long as 21 days. Here the favorable postoperative survival time appears to be from 10 to 14 days. After appropriate periods of time the animals were sacrificed and the degenerated and normal nerves were secured and prepared for histological study and quantitative analysis by methods described previously by the writer.²

Results. The total number of axons in the 18 cervical sympathetic trunks of the unoperated sides (Table I) ranges from 5404 to 10127 and averages 7422. The differential count shows that the myelinated fibers outnumber (average 67% myelinated) the unmyelinated fibers in 15 of the 18 normal trunks (Table I[†]). In 4 of the 15 (cats 111, 6B, 10B, and 120) the margin of excess is not great (average 55% myelinated). In 3 of the 18 (cats 10, 3 and 117), moreover the myelinated fibers comprise, respectively 43, 48 and 37% of the total number of axons enumerated in each normal trunk. In only one instance (cat 3B, 96%) is the normal trunk almost completely made up of myelinated fibers.

TABLE I.

Cat No.	Surgery	Survival time in days	Nerve fibers in cervical sympathetic trunk after ablation of its thoracic preganglionic axons					
			Operated side			Unoperated side		
			Total axons	Myelinated axons	Unmyelinated axons	Total axons	Myelinated axons	Unmyelinated axons
2B	RS	10	311 (5) +	13	298	6854	4954 (72) ‡	1900 (24) *
1B¶	RS	10	111 (2) +	5	106	7261	5031 (70) ‡	2230 (30) *
5B¶	RS	12	126 (2) +	24	102	8405	6039 (72) ‡	2366 (27) *
9B¶	RS	12	554 (7) +	5	549	7549	5283 (70) ‡	2266 (25) *
111¶	RS	13	1473 (24) +	12	1471	6124	3508 (57) ‡	2616 (25) *
6B¶	RS	14	285 (3) +	3	282	8799	5087 (58) ‡	3712 (40) *
3B	RS	14	221 (3) +	7	214	7312	7036 (96) ‡	276 (1) *
4B	RS	14	386 (5) +	67	319	8127	5592 (69) ‡	2535 (29) *
10B	RS	14	283 (3) +	2	281	8608	4483 (52) ‡	4125 (46) *
120	G	14	490 (6) +	38	452	8083	4207 (52) ‡	3876 (44) *
10	G	20	2619 (33) +	8	2611	7983	3400 (43) ‡	4583 (37) *
3	R	21	410 (4) +	4	406	10127	4841 (48) ‡	5286 (50) *
117	G	21	420 (6) +	7	413	7394	2702 (37) ‡	4692 (61) *
148†	R	37	2535 (38) +	164	2371	6681	3705 (55) ‡	2976 (15) *
149†	R	49	1149 (17) +	49	1100	6927	5555 (80) ‡	1372 (5) *
147†	R	94	1535 (28) +	262	1273	5404	4299 (79) ‡	1105 (0) *
144†	G	104	1918 (34) +	204	1714	5622	3414 (61) ‡	2208 (13) *
142†	G	107	2117 (33) +	101	2016	6342	3801 (60) ‡	2541 (12) *

† = Foley, James O., and DuBois, Franklin S., *J. Comp. Neur.*, 1940, **72**, 587.

+ = % of total axons of the nerve of the unoperated side. Subtract from 100% for determination of total preganglionic axons.

‡ = % of total axons of unoperated side which is myelinated.

* = % of preganglionic axons which is unmyelinated. Method of determination described in previous publication.²

¶ = Surgery done on right side, all others on left.

RS = Combined sympathectomy and section of rami of stellate ganglion.

R = Rhizotomy of the first 9 thoracic spinal nerves.

G = Ganglionectomy of the first thoracic nerves.

The degenerated sympathetic trunks[‡] of the cats which lived for 10 to 21 days after surgery contain from 111 to 2619 axons and these represent 2 to 33% (Table 1⁺) of the total number of nerve fibers in the intact trunk of the unoperated side. The average number of axons in these 13 degenerated nerves is 592, and this constitutes 8% of the total average number of nerve fibers of the unoperated trunks. On the average, more axons were found in the degenerated left (623 fibers) than in the degenerated right (510 fibers) (Table I[¶]) cervical sympathetic trunk. The differential count of the residual fibers (Table

I) in the degenerated trunks of the animals with short survival times (10 to 21 days) shows that relatively few (average 2%) of the total number of persistent axons are myelinated, most are unmyelinated.

A comparison of the number of myelinated and unmyelinated fibers in the operated trunks (Table I) shows a significant and constant relationship to the postoperative survival time. On the average, there are approximately 10 times more myelinated fibers (156 as contrasted with 15) and almost 4 times more unmyelinated fibers (1695 as contrasted with 460) in the degenerated sympathetic trunks of the cats with long postoperative survival times (37 to 107 days) than in those of the animals with shorter postoperative survival times (10 to 21 days). The greater number

‡ This statement applies at all times to the main body of the trunk and does not include those fascicles which can be followed into it from the vagus and superior cervical ganglion.²

of nerve fibers in the degenerated nerves of the animals which lived longer than 21 days after surgery indicates that significant numbers of regenerated axons are present in the degenerated sympathetic trunks of the cats with long postoperative survival periods.

In 11 of the 13 sympathetic trunks, described here for the first time, the surgical procedures removed an average of approximately 95% (Table I⁺) of the total number of axons while in the remaining two 67 and 76% were removed. The present experiments indicate that the majority of nerve fibers in the cervical sympathetic trunk are preganglionic axons from thoracic levels of spinal cord. The deleted preganglionic axons are predominantly myelinated since the myelinated axons represent, in most cases, the most numerous type of nerve fiber in the cervical sympathetic trunk and almost all of them are removed by the surgery employed (Table I). Significant numbers of preganglionic axons, however, are unmyelinated and these range from 1 to 61% and average 34% (Table I*).

Discussion. The results obtained in the present research support the general thesis of the previous report;² namely, that large numbers of the preganglionic fibers of the cervical sympathetic trunk are unmyelinated and that variable numbers of axons remain in the cervical sympathetic trunk after the preganglionic fibers have been eliminated. The present findings, however, indicate that the earlier results² were complicated by regeneration. The number of residual axons reported previously were too high since their normal number was augmented by regeneration. Furthermore, the percentages of unmyelinated preganglionic axons which were recorded were too low since the majority of the regenerated axons were unmyelinated and their presence adversely affected the calculation² of the number of unmyelinated preganglionic axons.

Caution should be exercised in drawing conclusions on the ratio which exists between preganglionic and postganglionic neurons

when such conclusions are based only on an enumeration of the myelinated axons since the present observations indicate that significant numbers of the axons in the cervical sympathetic trunk are unmyelinated. Confirmation of this contention, previously indicated² and now reemphasized, is furnished by the recent findings of Wolf.³ This investigator has demonstrated that the ratio between preganglionic axons in the cervical sympathetic trunk and cells in the superior cervical ganglion is materially reduced, from the ratio reported previously,¹ when the unmyelinated fibers of the cervical sympathetic trunk are taken into consideration. Furthermore, the observation by the writer that not all of the nerve fibers in the cervical sympathetic trunk are preganglionic axons indicates the desirability of a further revision of the ratios between preganglionic and postganglionic neurons in the cervical sympathetic trunk.

Summary. The total number of nerve fibers enumerated in 18 normal sympathetic trunks, varied from 5404 to 10127. In 15 of the 18 nerves the myelinated exceeded the unmyelinated axons but in the majority of the 15 nerves the excess of myelinated over unmyelinated axons is not great. In only one instance was the trunk almost completely composed of myelinated fibers (96%).

A variable number of nerve fibers (111 to 2619) remains in the cervical sympathetic trunk after its preganglionic axons have been eliminated. These residual fibers comprise 2 to 33% of the total number of nerve fibers in the cervical sympathetic trunk and the majority of them are unmyelinated.

The majority (67 to 98%) of the nerve fibers in the cervical sympathetic trunk are preganglionic axons from thoracic levels of spinal cord. Considerable variation exists in the ratio between myelinated and unmyelinated preganglionic axons in different cats, the unmyelinated ranging from 1 to 61% and averaging 34%.

³ Wolf, George A., *J. Comp. Neur.*, 1941, **75**, 235.