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DISTRIBUTION OF THE SYMPATHETIC RAMI TO THE BRACHIAL PLEXUS

ITS RELATION TO SYMPATHECTOMY AFFECTING THE
UPPER EXTREMITY*

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Extirpation of the stellate ganglion or section of the gray rami which connect this ganglion with the brachial plexus has become a recognized surgical procedure, especially in diseases involving the blood vessels of the upper extremity. The aim of this procedure in diseases of the blood vessels is vasomotor denervation of the extremity. Extirpation of the stellate ganglion alone, or section of the gray rami which connect it with the brachial plexus, however, does not completely eliminate the sympathetic nerves of the upper limb in a large percentage of cases. The operation has failed to produce the desired results in certain cases, probably because of incomplete sympathetic denervation of the blood vessels which were involved.

During the progress of studies involving the gray rami associated with the brachial plexus and the distribution of sympathetic fibers in the upper extremity, my attention was called to the inconstant intra thoracic ramus that connects the first and second thoracic nerves as a possible pathway through which sympathetic fibers that leave the sympathetic trunk below the stellate ganglion might enter the first thoracic nerve and become incorporated in nerves arising from the brachial plexus. Accordingly, the present study of the lower cervical and upper thoracic portions of the sympathetic trunks and the communicating rami joining the spinal nerves which contribute to the innervation of the upper extremity was undertaken in order to obtain more exact knowledge regarding the sources of the sympathetic innervation of the upper limb and, if possible, to afford a rational basis for an operative procedure that will in all cases effectively deprive the blood vessels of this limb of their vasomotor nerves.

The chief sources of sympathetic fibers to the upper extremity are the middle cervical and stellate ganglions. These ganglions, as well as the upper thoracic sympathetic ganglions, are extremely variable. Not infrequently the middle cervical ganglion is absent; when it is present, it is generally located about the level of the body of the sixth cervical vertebra. It is usually connected through the gray rami with the fifth and sixth cervical nerves; in some instances, also with the fourth and seventh cervical nerves (Potts, 1925).¹ In some instances the middle cervical ganglion lies close to the stellate ganglion. In such cases, the communicating rami arising from the cervical sympathetic trunk may join the fifth and sixth and possibly the fourth and seventh cervical nerves.

A discrete, inferior, cervical sympathetic ganglion occurs but rarely, if at all, in man. This ganglion commonly fuses with the first thoracic sympathetic ganglion to form a stellate ganglion. In some instances the second thoracic sympathetic ganglion is also incorporated in the stellate ganglion. This ganglion varies greatly in size and form. It commonly lies about the level of the neck of the first rib, but it may occupy a somewhat lower position. Gray rami arising from the stellate ganglion join the seventh and eighth cervical and the first thoracic nerves. Not infrequently, especially if the middle cervical ganglion is absent, a gray ramus from the stellate ganglion joins the sixth cervical nerve. At times the stellate ganglion sends a gray ramus to the second thoracic nerve. The first thoracic nerve also sends a white ramus into the stellate ganglion.

Although an intrathoracic ramus of the second thoracic nerve joins the first thoracic nerve in a large percentage of cases, the second thoracic nerve is not commonly regarded as contributory to the brachial plexus. In forty-eight cadavers examined during the present study, an intra thoracic ramus connecting the first and second thoracic nerves was present bilaterally in twenty-one and unilaterally in nine. In the twenty-one cadavers in which it was present bilaterally, this ramus was described as large in ten, of medium size in seven and as small in four. In the nine cadavers in which it was present on only one side, it was described as of medium size in five and as small in four.

According to statements in the textbooks regarding this inconstant ramus of the second thoracic nerve, it may join only the intercostal ramus of the first thoracic nerve or only the brachial plexus, or it may contribute fibers to both the first intercostal nerve and the brachial plexus. In the cadavers examined in the present study, this ramus joined the first intercostal nerve distal to its origin from the first thoracic nerve in only six cases, in all of which it was described as medium or small. In all the other cases it joined the first thoracic nerve proximal to the origin of the first intercostal nerve. If the ramus in question is small, all of its fibers may still be incorporated in the first intercostal nerve, although a contribution of fibers from the second thoracic nerve to the brachial plexus is not precluded. Not infrequently this ramus is actually larger than the first intercostal nerve. In such instances the second thoracic nerve clearly contributes fibers to the brachial plexus.

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1. Potts, T. K.: The Main Peripheral Connections of the Human Sympathetic Nervous System, J. Anat. 59:129, 1925.

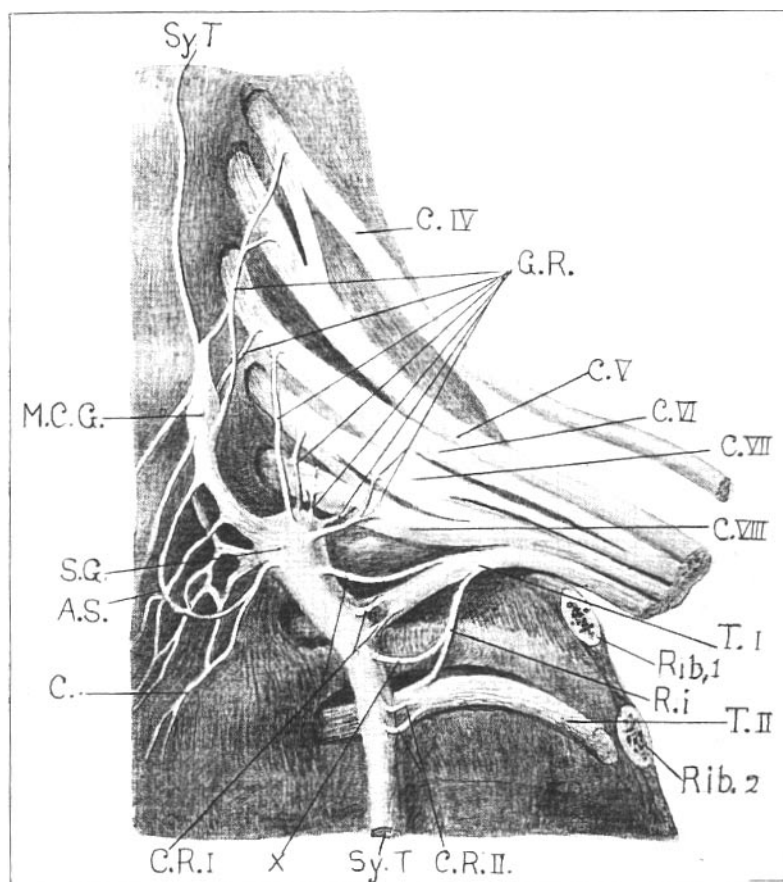


Fig. 1. - Drawing from the cadaver to illustrate the inconstant intrathoracic ramus from the second to the first thoracic nerve and the communicating rami joining the brachial plexus. In the illustrations, A. S. indicates the ansa subclavia; C., the cardiac nerves; C. IV to C. VIII, cervical nerves; C. R. I, communicating rami to first thoracic nerve; C. R. II, communicating rami to second thoracic nerve; G. R., gray communicating rami to cervical nerves; M. C. G., middle cervical ganglion; R. i, inconstant intrathoracic ramus from second to first thoracic nerve; S. G., stellate ganglion; Sy. T., sympathetic trunk; X, sympathetic ramus joining the ramus from the second to the first thoracic nerve; T. I, first thoracic nerve; T. II, second thoracic nerve.

The second thoracic nerve is commonly connected with the second thoracic sympathetic ganglion or the sympathetic trunk by a white and a gray ramus. In some of the cases in the present study, a gray ramus from the second thoracic sympathetic ganglion or the sympathetic trunk was traced directly into the ramus connecting the first and second thoracic nerves (fig. 1 x). In other cases a ramus from the stellate ganglion was also traced into this ramus. In all cases in which a gray ramus was traced from the second thoracic ganglion or the sympathetic trunk directly into the ramus joining the first thoracic nerve, one or more communicating rami also joined the second thoracic nerve. Not infrequently, a communicating ramus joined the second thoracic nerve at or near the point of origin of the ramus that joins the first thoracic nerve. Sometimes it was apparent that some of the fibers in the communicating ramus joined the ramus leading to the first thoracic nerve. In a few instances a small ramus was traced into the first thoracic nerve directly from the second thoracic sympathetic ganglion or the communicating ramus connecting this ganglion with the second thoracic nerve.

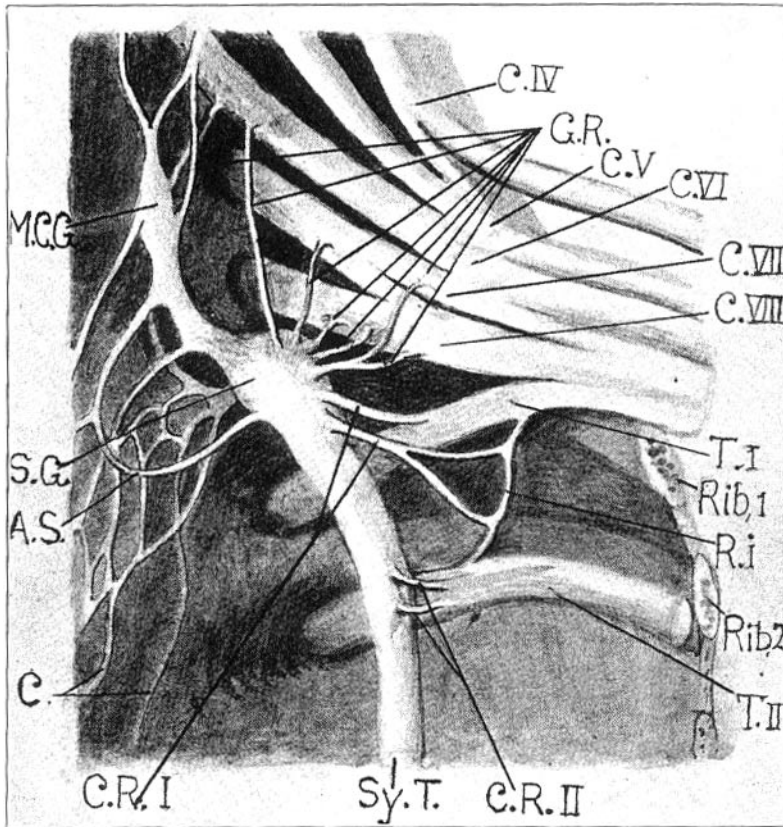


Fig. 2. - Drawing from the cadaver to illustrate variation in the inconstant intrathoracic ramus from the second to the first thoracic nerve.

Figure 3 illustrates a large intrathoracic ramus that arises from the second thoracic nerve farther distally than usual but joins the first thoracic nerve proximal to the origin of its intercostal ramus.

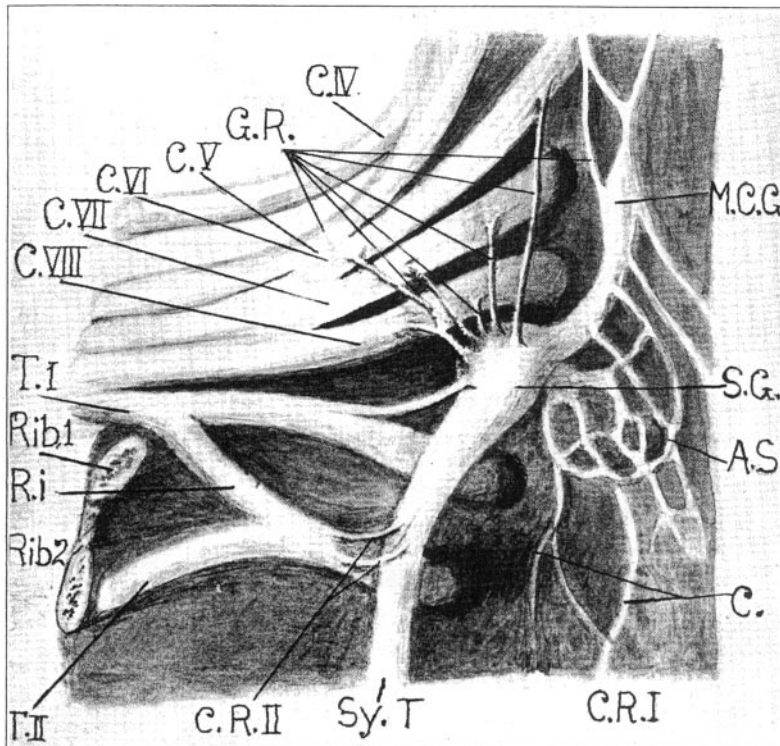


Fig. 3. - Drawing from the cadaver to illustrate a very large intrathoracic ramus from the second to the first thoracic nerve.

Microscopic study of sections of the intrathoracic ramus joining the first and second thoracic nerves taken at autopsy in two cases in which this ramus was well developed revealed that myelinated fibers occur there more frequently than they do in sections of spinal nerves distal to the communicating rami. Fibers of small caliber with thin myelin sheaths occur in abundance in these sections; thinly myelinated fibers of small caliber also occur in abundance in sections of the gray rami in these cases. These observations regarding the frequency of unmyelinated fibers in the ramus joining the first and second thoracic nerves in man were corroborated in sections of this ramus taken from animals (cats and dogs). While a small caliber and a thin myelin sheath or complete absence of myelin are not absolute criteria of the sympathetic nature of nerve fibers, the majority of these fibers in the ramus doubt less are sympathetic.

The foregoing observations show clearly that the intrathoracic ramus connecting the first and second thoracic nerves, which is present in man in a large percentage of cases, contains sympathetic fibers. Whenever this ramus joins the first thoracic nerve proximal to the origin of the first intercostal nerve it constitutes a pathway through which sympathetic fibers that leave the sympathetic trunk below the stellate ganglion enter the brachial plexus.

Recent studies of the innervation of the arteries of the extremities in mammals (Hirsch, 1925;² Wiedopf, 1925,³ and Kerper, 1927)⁴ show clearly that sympathetic fibers which are carried peripherally in the larger nerve trunks join the arteries at intervals along their course. Sympathetic fibers reach the vessels of the extremities mainly via these nerves. Few if any sympathetic fibers extend peripherally along the walls of the vessels. The nerves that supply the voluntary muscles include not only the sympathetic fibers which, as shown by Boeke (1913, 1927)⁵ and others, terminate on striated muscles, but also sympathetic fibers which supply the blood vessels in the muscle (Kuntz 1927).⁶ As the first thoracic nerve contributes largely to both the median and ulnar nerves, the sympathetic fibers contained in it, including those which enter via the ramus from the second thoracic nerve when ever this ramus is present, are relatively widely distributed to blood vessels and other tissues in the upper extremity.

2. Hirsch, L.: Ueber die Nervenversorgung der Gefasse im Hinblick auf die Probleme der periarteriellen Sympathektomie, Arch. f. klin. Chir. 137:281, 1925.

3. Wiedopf, O.: Der Verlauf der Gefassnerven in den Extremitaten und deren Wirkung bei der periarteriellen Sympathektomie, Miinchen. med. Wehnschr. 72:413, 1925.

4. Kerper, A. H.: The Innervation of the Arteries of the Extremities, Thesis, to be published.

5. Boeke, J.: Die doppelte (motorische und sympathische) efferente Innervation der quergestreiften Muskelfasern, Anat. Anz. 44:343, 1913. Die morphologische Grundlage der sympathischen Innervation der quergestreiften Muskelfasern, Ztschr. f. mikr-anat. Forsch. 8:561, 1913.

6. Kuntz, A.: On the Occurrence of Sympathetic Nerve Fibers in Muscles of the Extremities Following Experimental Degeneration of the Spinal Nerves, J. Comp. Neurol., 1927, vol. 43.

In view of the foregoing anatomic data, extirpation of the stellate ganglion or section of the gray rami connecting this ganglion with the brachial plexus is inadequate to insure complete sympathetic denervation of the blood vessels of the upper extremity in cases in which the inconstant intrathoracic ramus connecting the first and second thoracic nerves is present. In such cases, complete sympathetic denervation of the upper extremity requires extirpation of the stellate ganglion and of the upper portion of the thoracic sympathetic trunk to the level below the communicating rami of the second thoracic nerve, or section of the communicating rami of the second thoracic nerve and any peripheral rami arising from the thoracic sympathetic trunk above this level, in addition to section of the gray rami connecting the stellate and middle cervical ganglions with the brachial plexus.