Anatomic variations of the T2 nerve root (including the nerve of Kuntz) and their implications for sympathectomy

In-Hyuk Chung, MD, PhD[a]
Chang-Seok Oh, MD, PhD[b]
Ki-Seok Koh, PhD[c]
Hee-Jin Kim, DDS, PhD[d]
Hyo-Chae Paik, MD[e]
Doo-Yun Lee, MD, PhD[e]

Objective: The aim of this study was to clarify the anatomic variations of the intrathoracic nerve of Kuntz, and this should help delineate the resection margins during video-assisted thoracic sympathectomy.

Methods: Sixty-six thoracic sympathetic chains of 39 adult Korean cadavers were dissected on both sides of the thorax in 27 cadavers (54 sides) and on one side in 12 cadavers (12 sides).

Results: The intrathoracic nerve was observed in 45 (68.2%) sides and was present bilaterally in 48.1% of cadavers. No intrathoracic nerve or ascending ramus communicans arising from the second thoracic nerve was observed in only 5 (7.6%) sides. The diameter of the intrathoracic nerve was 1.25 ± 0.55 mm on average. The arising point of the intrathoracic nerve from the second thoracic nerve was 7.3 mm on average from the sympathetic trunk. Presence of the stellate ganglion was noted in 56 (84.8%) sides, and 6 (9.1%) sides showed a single large ganglion formed by the stellate and the second thoracic sympathetic ganglia. The second thoracic sympathetic ganglion was most commonly located (50%) in the second intercostal space.

Conclusion: The anatomic variations of the intrathoracic nerve of Kuntz and the second thoracic sympathetic ganglion were characterized in human cadavers. It is hoped that this study will help to improve the recurrence of symptoms caused by the intrathoracic nerve in an upper thoracic sympathectomy for hyperhidrosis.

GTS

From the Departments of Anatomy[a] and Thoracic and Cardiovascular Surgery,[e] Yonsei University College of Medicine, Seoul, Korea, the Department of Anatomy,[b] Sungkyunkwan University School of Medicine, Suwon, Korea, the Department of Anatomy,[c] Medical College, Konkuk University, Chungju, Korea, and the Department of Oral Biology,[d] Yonsei University College of Dentistry, Seoul, Korea.

This study was supported by Brain Korea 21 Project for Medical Science, Yonsei University in 2001.

Received for publication June 4, 2001; revisions requested July 12, 2001; revisions received Aug 2, 2001; accepted for publication Aug 6, 2001.

Address for reprints: In-Hyuk Chung, MD, PhD, Professor, Department of Anatomy, Yonsei University College of Medicine, Seodaemoonku Shinchondong 134, Seoul 120-752, Korea (E-mail: chinhy@yumc.yonsei.ac.kr).

J Thorac Cardiovasc Surg 2002;123:498-501

0022-5223/2002 $35.00 + 0 **12/1/119340**

doi:10.1067/mtc.2002.119340

Endoscopic thoracic sympathectomy is an effective method of relieving the symptoms of craniofacial, palmar, or axillary hyperhidrosis.[1-3] Some patients experience postoperative symptom recurrence, which may be due to incomplete resection or the presence of anatomic variation and axonal regrowth of the sympathetic trunk.[4,5] Such anatomic variations are considered to involve the intrathoracic nerve of Kuntz (INK). Kuntz[6] described an inconstant intrathoracic ramus connecting the first and second thoracic nerves, involving sympathetic nerve fibers reaching the brachial plexus without passing through the sympathetic trunk. However, the detailed anatomy of this ramus has not been well documented.

The purpose of this study was to identify the anatomic variations of the INK and to help delineate the resection margins during video-assisted thoracic sympathectomy.

Materials and Methods

Sixty-six thoracic sympathetic chains of 39 adult Korean cadavers (male, 23; female, 16) were dissected. Both sides of the thorax were used in 27 cadavers (54 sides), and one side was used in 12 cadavers (12 sides). After removing the sternum and ribs from the bilateral

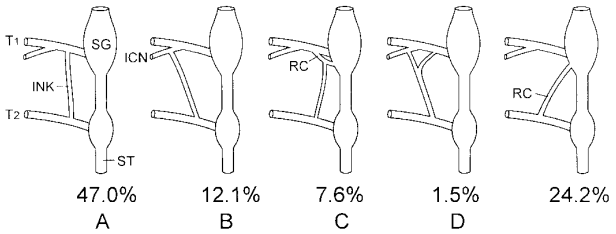

Figure 1. Four types of INK and ramus communicans from the T2 nerve to the stellate ganglion. *ICN*, Intercostal nerve; *RC*, ramus communicans; *SG*, stellate ganglion; *ST*, sympathetic trunk.

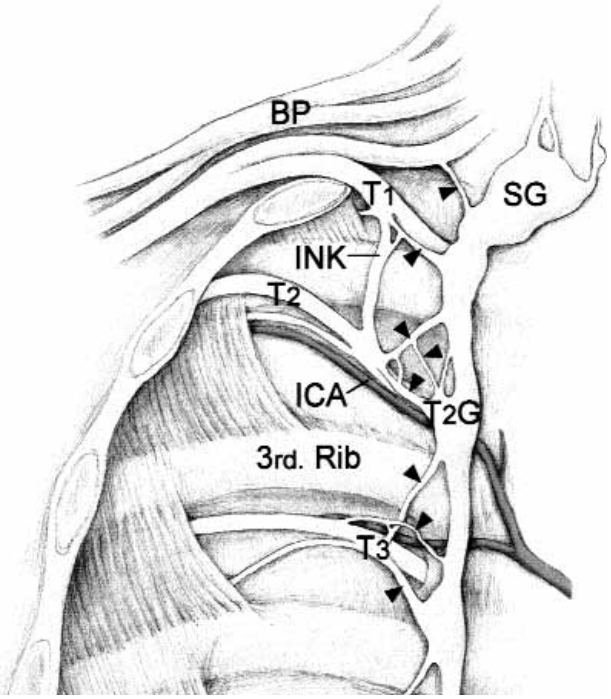

Figure 2. Upper thoracic sympathetic trunk. *BP*, Brachial plexus; *ICA*, intercostal artery; *RC*, ramus communicans; *SG*, stellate ganglion; *ST*, sympathetic trunk. *Arrowheads* indicate the ramus communicans.

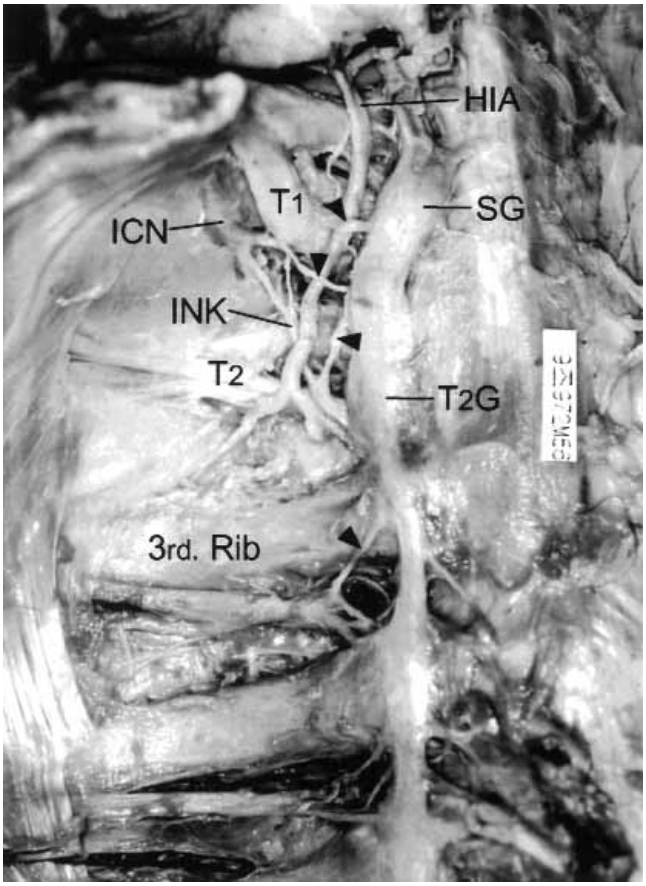

Figure 3. The INK from the second thoracic nerve divides and connects the first intercostal and thoracic nerves. The second thoracic sympathetic ganglion fuses with the stellate ganglion. The highest intercostal artery descends and crosses the INK. *HIA*, Highest intercostal artery; *ICN*, intercostal nerve; *SG*, stellate ganglion; *ST*, sympathetic trunk; *T2G*, second thoracic sympathetic trunk. *Arrowheads* indicate the ramus communicans.

midaxillary line, the intrathoracic organs were removed to expose the posterior mediastinum. We focused our dissection on the anatomy of the INK.

The diameter of the INK was defined as the mean of the long and short diameters of the middle portion of the INK. We measured the distance from the arising point of the INK from the second thoracic nerve to the sympathetic trunk. All measurements were made with digital calipers (Mitutoyo).

Results

Among the 66 thoracic sympathetic chains dissected, INK was observed in 45 (68.2%), and it was present bilaterally in 48.1% of 27 cadavers. INK was classified into 4 types according to the connecting nerves (Figure 1): type A, connection from the T2 to the T1 nerve (Figure 2); type B, connection from the T2 to the first intercostal nerve; type C, INK originated from the T2 nerve and was connected to the ramus communicans between the stellate ganglion and the T1 nerve; and type D, INK was branched and connected from the T2 nerve to the T1 nerve and the first intercostal nerve (Figure 3). Forty-seven percent were type A, 12.1% were type B, 7.6% were type C, and 1.5% were type D. Twenty-one sides did not have an INK, but 16 (24.2%) sides had ramus communicans connecting from the T2 nerve to the stellate ganglion to appear as though it had an INK. The INK or other ascending ramus communicans from the T2 nerve was absent in only 7.6%. The INK was noted between the T2 and T3 nerves in 5 (7.6%) sides.

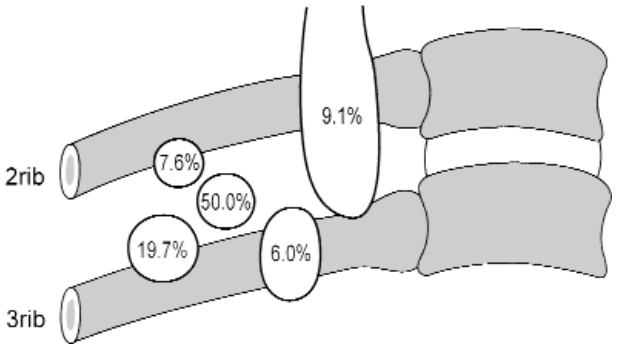

Figure 4. Location of the second thoracic sympathetic ganglion.

The distance from the INK to the sympathetic trunk was 7.3 mm on average: 28.3% were between 0 and 5 mm, 52.2% were between 5 and 10 mm, and 19.5% were between 10 and 15 mm. The diameter of the INK was on average 1.25 ± 0.55 mm (range, 0.38-3.38 mm).

The stellate ganglion was noted in 56 (84.8%) sides, and among these, 6 (9.1%) sides had a single large ganglion formed by a combining of the stellate and the T2 sympathetic ganglia (Figure 3).

The location of the T2 sympathetic ganglion was grouped according to the relationship with the second and third ribs (Figure 4). The most frequent location of the ganglion was in the second intercostal space (50.0%), and it was followed by the upper border of the third rib (19.7%), elongated from the second to the third rib (9.1%), where the T2 sympathetic ganglion seemed to be fused to the stellate ganglion, the lower border of the second rib (7.6%), and from the second to the third intercostal space over the entire length of the third rib (6.0%), where the T2 sympathetic ganglion appeared to be fused with the T3 sympathetic ganglion. In 7.6% of 66 cases, the T2 sympathetic ganglion could not be identified.

Discussion

Increased interest and the development of better equipment in video-assisted thoracic surgery have allowed improved management in patients with hyperhidrosis.[7-9] Clear vision of the thoracic sympathetic chain is possible by means of video-assisted thoracic surgery, and many are satisfied with the result of surgical treatment. However, there are instances of failed symptom improvement, which are believed to be due to incomplete thoracic sympathectomy[4] caused by the INK directly connecting the second or third thoracic ganglion to the brachial plexus.

The second thoracic nerve is not generally regarded as contributory to the brachial plexus. However, Kuntz[6] examined 48 cadavers and noted a high incidence (62.5%) of intrathoracic ramus connecting the first and second thoracic nerve. Moreover, whenever this ramus joins the first thoracic nerve, it is probably that the sympathetic fibers below the stellate ganglion maintain connection with the brachial plexus.

There are relatively few reports[10,11] concerning the surgical landmarks during sympathectomy. The second thoracic segment is the most important sympathetic innervation to the upper extremity,[12] and variations in the number of connections made by rami communicans between the second intercostal nerve and the second sympathetic thoracic ganglion are possible.[4] This variation causes some of the sympathetic innervation to remain intact during sympathectomy, and these may adopt the function of the resected nerve bundles and cause remnant hyperhidrosis.

The recommended surgical technique of sympathectomy has been reported to avoid postoperative hyperhidrosis.[13] The sympathetic chain should be resected from immediately below the stellate ganglion to the level just above the T3 sympathetic ganglion, and the INK should also be divided to prevent the possibility of gray rami connecting directly from the stellate ganglion to the brachial plexus.

The anatomy around the T2 sympathetic ganglion is of utmost importance in the incidence of remnant symptoms after T2 or T3 sympathectomy. Type A INK, which has a connection between the T1 and T2 nerves, was the most common type (47%), and in these cases a connecting branch between the stellate ganglion and the INK was present. In one case of type A, there were 2 INKs arising from the T2 sympathetic ganglion, and this form of variation carries a higher chance of remnant symptoms postoperatively caused by the greater likelihood of partial ligation of the INK.

The main body of the T2 sympathetic ganglion is usually located in the second intercostal space, and according to its relationship with the third rib, the T2 sympathetic ganglion was classified into 3 subtypes[14] and found to be easily recognized at the upper border of the third rib in 85% of the cases. Our data are similar, and the T2 sympathetic ganglion was to be located at the margin of the second intercostal space or the upper margin of the third rib in 78.8% of cases.

One needs to bear in mind the location of the INK arising from the sympathetic trunk. Because 19.5% arise between 10 and 15 mm from the trunk, with a mean distance of 7.3 mm, it is necessary to cut parietal pleura over the rib longitudinally for at least 1.5 cm laterally from the sympathetic trunk to be sure of successful INK ligation. And it is probably worth rementioning that cases that remain symptomatic postoperatively are presumably caused by an incomplete margin of resection near the INK. In some patients who have undergone reoperation because of only a partial response to surgical treatment, the symptoms disappear after wider longitudinal resection over the ribs, which supports our surgical technique of pleural resection for a distance of at least 1.5 cm lateral from the sympathetic trunk.

References

1. Chuang KS, Liou NH, Liu JC. New stereotactic technique for percutaneous thermocoagulation upper thoracic ganglionectomy in cases of palmar hyperhidrosis. *Neurosurgery.* 1988;22:600-4.
2. Mockus MB, Rutherford RB, Rosales C, Pearce H. Sympathectomy for causalgia. Patient selection and long term results. *Arch Surg.* 1987; 122:668-72.
3. Noppen M, Herrogodts P, D'Haese J, Vincken W. A simplified T2-T3 thoracoscopic sympathicolysis technique for the treatment of essential hyperhidrosis: short-term results in 100 patients. *J Laparoendosc Surg.* 1996;6:151-9.
4. van Rhede van der Kloot E, Drukker J, Lemmens HAJ, Greep JM. The high thoracic sympathetic nerve system—its anatomic variability. *J Surg Res.* 1986;40:112-9.
5. Lee DY, Hong YJ, Shin HK. Thoracoscopic sympathetic surgery for hyperhidrosis. *Yonsei Med J.* 1999;40:589-95.
6. Kuntz A. Distribution of the sympathetic rami to the brachial plexus: its relation to sympathectomy affecting the upper extremity. *Arch Surg.* 1927;15:871-7.
7. Moran KT, Brady MP. Surgical management of primary hyperhidrosis. *Br J Surg.* 1991;78:279-83.
8. Gossot D, Toledo L, Fritsch S, Celerier M. Thoracoscopic sympathectomy for upper limb hyperhidrosis: Looking for the right operation. *Ann Thorac Surg.* 1997;64:975-8.
9. Drott C, Göthberg G, Claes G. Endoscopic procedures of the upper-thoracic sympathetic chain. *Arch Surg.* 1993;128:237-41.
10. Kao MC. Video endoscopic sympathectomy using a fiberoptic CO2 laser to treat palmar hyperhidrosis. *Neurosurgery.* 1992;30:131-5.
11. Lin CC. A new method of thoracoscopic sympathectomy in hyperhidrosis palmaris. *Surg Endosc.* 1990;4:224-6.
12. Pick J. The identification of sympathetic segments. *Ann Surg.* 1957; 145:355-64.
13. Roos DB. Sympathectomy for the upper extremities: anatomy, indications and techniques. In: Rutherford R, editor. Vascular surgery. Philadelphia: WB Saunders; 1977. p. 460.
14. Chiou TSM, Liao KK. Orientation landmarks of endoscopic transaxillary T-2 sympathectomy for palmar hyperhidrosis. *J Neurosurg.* 1996;85:310-5.

GTS