The Nerve of Kuntz: Incidence, Location and Variations

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Abstract: Nerve of Kuntz is considered to be one of the causes of recurrence of symptoms following endo thoracic sympathectomy. This study was designed to explore the anatomic variations in the location and course of the intrathoracic nerve of Kuntz (INK). Bilateral dissection of the sympathetic chain and somatic nerves of the upper 5 intercostal spaces was undertaken in 25 adult cadavers. The total sample size comprised 25 cadavers (50 sides). The incidence of any connection between the first and second thoracic nerves (INK), the diameter of the INK, the distance from the arising point of the INK from the second thoracic nerve to the sympathetic trunk were noted. All measurements were made with digital calipers. The intrathoracic nerve of Kuntz was observed in 33 (66%) sides (54.5% left, 45.5% right) and was present bilaterally in 78.9% of 19 cadavers. The diameter of the intrathoracic nerve was 1.32±0.10 mm on the left and 1.29±0.12 mm on right side. The arising point of the intrathoracic nerve from the second thoracic nerve was 9.0±0.06 mm on left side and 1.06±0.06 mm on right side from the sympathetic trunk. In 80% of cases a collateral artery was present in relation to INK. It is concluded that second thoracic nerve contributes fibers to the brachial plexus that do not ascend in sympathetic trunk. These nerve fibers, the Nerve of Kuntz, pass up over the second rib level on their way to join the first thoracic nerve. To achieve successful results of endo thoracic sympathectomy it is imperative that all the sympathetic nerve fibers crossing the second rib level should be divided.

Key words: Sympathectomy, stellate ganglion, sympathetic chain, nerve of Kuntz.

INTRODUCTION

Endoscopic thoracic sympathectomy (ETS) is a surgical procedure, used to relieve the symptoms of craniofacial, palmar, or axillary hyperhidrosis,[1,2,3,4] facial blushing,[5] Raynaud’s disease,[6,7] and reflex sympathetic dystrophy.[8,9] There are reports of ETS being used to achieve cerebral revascularization for patients with moyamoya disease[10] and to treat headaches, hyperactive bronchial tubes[11], long QT syndrome,[12,13] causalgic pain[14], erythromelalgia[15], Burger’s disease[16], Prinzmetal’s angina[17], migraine[18] and in the treatment of chronic non-infectious rhinitis.[19] Sympathectomy is also effective in ameliorating the effects of frostbite injury, especially if performed within 36-72 hours of cold exposure.[20] Sympathectomy physically destroys sympathetic fibers anywhere in either of the two sympathetic trunks. The most common area targeted is the upper thoracic region, the part of the sympathetic trunk lying between the first and fifth thoracic vertebrae. The procedure has shown some failure rate and the symptoms may recur in a small proportion of patients, months or even years after surgery.[21,22,23,24,25,26] The second thoracic nerve is not generally regarded as contributory to the brachial plexus. However, an inconsistent intrathoracic ramus joining the 2nd intercostal nerve to the ventral ramus of the 1st thoracic nerve, proximal to the point where the latter gave a large branch to the brachial plexus, was found by Kuntz[27] and named after him. This nerve was considered to be carrying sympathetic fibers to the brachial plexus without passing through the sympathetic trunk,[27, 28, 29] and was held responsible for the recurrence of symptoms following sympathectomy. However, the detailed anatomy of the intrathoracic nerve including variations have not been well documented.

The aim of this study was to determine the incidence, location and variations in the neural connections of the intrathoracic nerve of Kuntz (INK).
MATERIALS AND METHODS

Bilateral dissections of the sympathetic chain and somatic nerves of the upper 5 intercostal spaces were undertaken in 25 adult cadavers. The total sample size comprised 50 sides. The incidence of any connection between the first and second thoracic nerves (INK), the diameter of the INK, the distance from the arising point of the INK from the second thoracic nerve to the sympathetic trunk were noted. Presence of stellate ganglion, location of 2nd thoracic ganglion, and presence of any other nerve crossing the 2nd rib, joining lower intercostal nerves with T1 nerve were noted. Occurrence of collateral artery and vein were also recorded. All measurements were made with digital caliper. All dissections were done in the dissection room of the college of Medicine, King Saud University on the cadavers used for teaching the medical students.

Discussion: In the present study, it is very clearly shown that there exist frequent connections between the 2nd and the 1st thoracic nerves, as reported earlier (27) and these may be the cause of failure of endothermic sympathectomies. In 31.6% of cadavers a double connection was found; one connecting the 2nd thoracic nerve with the stellate ganglion and the other connecting it to the 1st thoracic or intercostals nerve. This form of variation carries a higher chance of remnant symptoms postoperatively caused probably by partial ligation of the INK.

The preganglionic sympathetic fibers innervating the arm originate mostly from the third to the sixth spinal segments. The preganglionic neurons in the spinal cord are located in the lateral horn of the gray matter. The preganglionic myelinated fibers exit from the spinal cord in the thoracic spinal nerves, leave the thoracic nerve, enter the sympathetic chain via the white rami communicantes. In the sympathetic chain the preganglionic fibers may ascend or descend and finally synapse at various levels in the paravertebral thoracic sympathetic ganglia. The postganglionic unmyelinated fibers heading to the upper limb leave the sympathetic chain via the gray rami communicantes, join the thoracic spinal nerves, enter the brachial plexus and are distributed through different nerves to their end targets in blood vessels, sweat glands or hair follicles. The postganglionic fibers to the arm originate from T2–T3 ganglia26. Surgical studies indicate that the main ganglion for the sympathetic innervation to the upper limb might be at level of T429. The autonomic innervation of the sweat glands of the palms is solely sympathetic, which comes mainly from T2-T3 or even T430. Thus, the preganglionic fibers to the hand ascend along the sympathetic chain to reach and synapse onto their target postganglionic neurons31, 32.

Sympathectomy involves dissection of the main sympathetic trunk in the upper thoracic region thus interrupting neural messages that ordinarily would travel to many different organs, glands and muscles. It involves division of adrenergic, cholinergic and sensory fibers which elaborate adrenergic substances during the process of regulating visceral function33. The origin of the sympathetic innervation of the upper limb is important in surgical sympathectomy procedures. The second thoracic segment is the most important sympathetic innervation to the upper limb and it is at level of T430. Definite results of ETS are difficult to predict, because of considerable anatomic variations in sympathetic nerve distribution from patient to patient, and also due to variations in surgical techniques.

The anatomy of the upper thoracic sympathetic trunk with ganglia and its anatomical variations has also been previously studied in cadavers35. A fine
Fig. 1: Diagrammatic representation of variations in the connecting fibers between the 2nd thoracic nerve and the 1st thoracic nerve and the stellate ganglion (Blue lines), SG=satellite ganglion, T2G= 2nd thoracic ganglion, ST=sympathetic trunk, T1 = 1st thoracic nerve, T2 = 2nd thoracic nerve, ICN= First intercostal nerve.

Fig. 2: Variations in Kuntz nerve. SG=satellite ganglion, T2G= 2nd thoracic ganglion, T1 = 1st thoracic nerve, T2 = 2nd thoracic nerve. Connection between 2nd thoracic and 1st thoracic nerve (red arrow), connection between 2nd thoracic nerve and stellate ganglion (black arrow). A connection between 2nd thoracic ganglion and 3rd thoracic nerve is also shown (white thick arrow). Superior intercostal artery (white arrow) and subpleural vein (black arrow) can be seen.
network of smaller and larger nerve bundles was found which connect the sympathetic and spinal nerve systems. Light microscopical perikarya were identified in many nerve bundles[28]. The incidence of bi- and unilateral intercostal rami arising from the T-2 and connected to the T-1 nerve has been reported[36]. Aside from the nerve of Kuntz, multiple other aberrant pathways exist between the upper thoracic sympathetic ganglia and intercostal nerves. These anatomical variations are common and occur in some or another in more than half the population[37,38] and are of great clinical importance, as they enable fibers to bypass the sympathetic chain, and thus are probably one of the main reasons for failures of surgical procedures[39,40]. Unsuccessful sympathectomy manifests as persistent or recurrent sympathetic activity after a seemingly successful procedure. The causes of this phenomenon include misinterpretation of the sympathetic chain at thoracoscopy, alternate neural pathways via the nerve of Kuntz, and regeneration of the sympathetic chain. Though sympathetic nerve regeneration remains extremely uncommon[39] recurrence of the original symptoms due to nerve regeneration or nerve sprouting may also occur[41,42]. The capacity of sudomotor axons to reinnervate sweat glands by regeneration or reinnervate by the mechanism of collateral sprouting is a well-recognized phenomenon[43,44].

Several effects related to the sympathectomy surgery e.g. rib pain and dryness of the hands or face, decrease in the heart rate, damage to the lungs and Horner’s syndrome were observed by patients. Nerve damage is a possible risk, while bleeding and infection may also occur. Bleeding during and following the operation may be significant in up to 5% of patients[41].

We have observed the course of superior intercostal artery along with INK in 80% of the cases, that confirms the findings of a study by Chiou and Liao[45], in which this small vessel existed in 87.5% of the
cadavers examined, running consistently lateral to the parallel sympathetic chain at an average distance of 10 mm. The superior intercostal artery may be the source of bleeding.

From this study, it is apparent that there are neuronal contributions from T2 that pass up over the second rib level on their way to T1. To achieve successful results of endothoracic sympathectomy it is imperative that all sympathetic nerve fibers crossing the second rib level should be divided. The superior intercostal artery may serve as an important landmark for the surgical orientation.

REFERENCES


