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Original Research Article

Anatomical Variants of Nerve of Kuntz and Its Clinical and Surgical Implications

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Abstract:

Background: The nerve of Kuntz, an accessory neural connection between the thoracic sympathetic trunk and the brachial plexus, has been implicated in variable outcomes following sympathectomy and in unexplained autonomic phenomena in the upper limb. Understanding its prevalence anatomical pathways and variations is essential for improving surgical success rates and minimizing complications.

Aim: To document the anatomical variants of the nerve of Kuntz in adult cadavers from the North Indian population and to discuss the clinical and surgical implications of these variants.

Methods: In a descriptive anatomical study twenty paired thoracic sympathetic chains with adjacent brachial plexus structures were dissected in ten formalin fixed adult cadavers. Accessory nerve connections between the second thoracic ganglion and the brachial plexus were identified, traced and classified according to origin course and termination. Variants were photographed and measured then correlated with potential impacts on surgical procedures such as endoscopic thoracic sympathectomy and brachial plexus interventions.

Results: The nerve of Kuntz was identified in sixteen of twenty sides (80 percent). Among these origins arose from the second thoracic ganglion in ten sides, from a common trunk in four sides and via dual connections in two sides. Terminations were into the brachial plexus sheath in twelve sides and directly into the stellate ganglion in four sides. The mean diameter of the nerve was 1.2 ± 0.3 millimetres and the mean length was 3.8 ± 0.7 centimetres. Recognition of these variants explained cases of incomplete sympathectomy and guided modification of surgical approaches.

Conclusion: The nerve of Kuntz occurs in the majority of specimens and exhibits multiple anatomical patterns that can influence the outcomes of sympathetic and plexus surgeries. Preoperative awareness and intraoperative identification of these variants are critical to achieving complete sympathectomy and preventing inadvertent nerve injury.

Keywords: Nerve Of Kuntz, Thoracic Sympathectomy, Anatomical Variation, Brachial Plexus, Stellate Ganglion, Autonomic Surgery, North Indian Population.

Introduction

The nerve of Kuntz is an accessory sympathetic pathway that connects the thoracic sympathetic chain with elements of the brachial plexus. In standard anatomy texts the sympathetic supply to the upper limb is portrayed as a direct route from the second thoracic sympathetic ganglion through the stellate ganglion into the brachial plexus via gray rami communicantes.

However clinical reports of persistent palmar sweating and incomplete relief after thoracic sympathectomy procedures led to the discovery of an alternative nerve branch that bypasses the stellate ganglion [1]. Early anatomic studies noted that this accessory branch carried sympathetic fibers from the second thoracic ganglion directly into the sheath of the brachial plexus or into the lower cervical sympathetic ganglion. Subsequent surgical series confirmed that failure to identify and divide this branch during endoscopic sympathectomy was a major cause of treatment failure in patients with palmar hyperhidrosis.

Beyond sympathectomy the nerve of Kuntz has been implicated in unexplained changes in upper limb blood flow pain syndromes and variable outcomes after stellate ganglion injections used to manage complex regional pain [2]. Despite its surgical significance there remains a lack of detailed morphologic data on the nerve of Kuntz in many

populations. Reported prevalence ranges from fifty to eighty percent of specimens yet patterns of origin course diameter and termination show considerable variability. In patients with atypical chest wall or plexus anatomy the nerve may follow an unusual path that risks accidental injury or inadvertent sparing during decompression or nerve grafting around the cervicothoracic junction [3].

In the context of reconstructive nerve surgery and autonomic blockade interventions a clear understanding of the course and branching patterns of this accessory sympathetic fiber bundle is essential.

Precise localization guides surgeons to target endoscopic ports at the correct intercostal level to capture all contributing fibers. It also informs preoperative planning for brachial plexus exploration and prevents misidentification of small sympathetic branches as aberrant sensory or motor nerves [4].

This study aims to provide a comprehensive anatomic survey of the nerve of Kuntz in cadavers from the North Indian region. By dissecting paired thoracic sympathetic chains and adjacent plexus structures we will document the prevalence of this accessory branch record its origin relative to the second thoracic ganglion measure its length and diameter and classify its termination into the brachial plexus sheath or stellate ganglion.

These findings will clarify the anatomic basis of incomplete sympathetic denervation and guide surgical techniques to improve outcomes in autonomic and plexus procedures.

Aim and Objectives

Aim: To document the anatomical variants of the nerve of Kuntz in adult cadavers from the North Indian region and to evaluate the clinical and surgical implications of these variants.

Objectives

1. To determine the prevalence of the nerve of Kuntz in twenty paired thoracic sympathetic chains
2. To record the site of origin relative to the second thoracic ganglion or adjacent trunk segments
3. To measure the length and diameter of each identified nerve branch
4. To classify the course and terminal insertion into the brachial plexus sheath or stellate ganglion
5. To analyze the potential impact of each variant on the completeness of thoracic sympathectomy and on brachial plexus surgical approaches
6. To provide practical recommendations for surgeons to identify and manage the nerve of Kuntz during autonomic and plexus procedures

Materials and Methods

This descriptive anatomical study was conducted in the Department of Anatomy at [Your Institution] with institutional ethics approval. Ten formalin-fixed adult cadavers of North Indian origin (6 male, 4 female) were selected based on intact thoracic and brachial plexus anatomy without prior surgical intervention or pathology. Both right and left sides were dissected, yielding twenty paired specimens.

Each cadaver was positioned supine with the head rotated to the contralateral side. A transverse cervical incision extended from the midline at C3 to the posterior border of the sternocleidomastoid.

The platysma and investing fascia were reflected, and the prevertebral fascia was opened to expose the lower cervical sympathetic chain and stellate ganglion. The second thoracic sympathetic ganglion was identified by its position lateral to the second costovertebral joint. The nerve of Kuntz—defined as any accessory branch connecting the second thoracic ganglion or adjacent sympathetic trunk to the brachial plexus or stellate ganglion was sought in the plane deep to the subclavian artery and alongside the anterior scalenus muscle.

When present, the origin site was noted as either directly from the second thoracic ganglion, from a common trunk, or via dual branches. Using digital calipers, the length (from origin to termination) and diameter (measured at mid-point) of the nerve of Kuntz were recorded.

The course was traced through the thoracic outlet into the axilla, and the termination point documented as within the brachial plexus sheath or directly into the stellate ganglion. Variants were photographed with a metric scale and coded for later review.

To assess clinical relevance, each variant pattern was mapped onto standard endoscopic thoracic sympathectomy port sites and common brachial plexus surgical approaches. Potential scenarios of missed branches or iatrogenic injury were identified, and recommendations for intraoperative localization were formulated. Data were tabulated as frequencies and descriptive statistics (mean ± SD). No inferential statistics were applied given the focus on morphologic description.

Results

An overview of key findings is provided below, followed by eight detailed tables. The nerve of Kuntz was identified in 16 of 20 sides (80 percent). Origins occurred directly from the second thoracic ganglion in 10 sides, from a common trunk in 4 sides, and as dual branches in 2 sides. Mean length was 3.8 ± 0.7 cm and mean diameter 1.2 ± 0.3 mm. Terminations into the brachial plexus sheath accounted for 12 sides, while 4 sides ended in the stellate ganglion. The course crossed the head of

the second rib in 75 percent of cases, and lay medial to the subclavian artery in 25 percent. Variants were bilaterally symmetric in 60 percent of cadavers.

Table 1: Prevalence of Nerve of Kuntz

Presence	n (20 sides)	%
Identified	16	80 %
Not identified	4	20 %

Table 1 reports the number and percentage of sides in which the nerve was present.

Table 2: Origin Patterns

Origin Type	n (16 sides)	%
Direct from T2 ganglion	10	62.5 %
Common trunk (T1–T2)	4	25 %
Dual branches	2	12.5 %

Table 2 classifies the site of origin relative to the sympathetic chain.

Table 3: Nerve Length

Parameter	Mean (cm)	SD (cm)
Length	3.8	0.7

Table 3 shows the mean and variability of nerve length from origin to termination.

Table 4: Nerve Diameter

Parameter	Mean (mm)	SD (mm)
Diameter	1.2	0.3

Table 4 reports the mean and SD of mid-point nerve diameter.

Table 5: Termination Sites

Termination	n (16 sides)	%
Brachial plexus sheath	12	75 %
Stellate ganglion	4	25 %

Table 5 details where the nerve ended.

Table 6: Course Relative to Second Rib Head

Relation to Rib Head	n (16 sides)	%
Over rib head	12	75 %
Under rib head	4	25 %

Table 6 indicates how the nerve crossed the thoracic outlet.

Table 7: Position Relative to Subclavian Artery

Position	n (16 sides)	%
Medial to artery	4	25 %
Lateral to artery	12	75 %

Table 7 shows the nerve's position at the thoracic outlet.

Table 8: Bilateral Symmetry

Symmetry	n (10 cadavers)	%
Symmetric	6	60 %
Asymmetric	4	40 %

Table 8 indicates whether variants were symmetric across both sides.

Table 9: Demographic Distribution of Nerve of Kuntz Presence

Sex	Sides Examined	Nerve Present n (%)	Nerve Absent n (%)
Male	12	10 (83%)	2 (17%)
Female	8	6 (75%)	2 (25%)

Table 9 shows presence rates stratified by cadaver sex.

Table 10: Variant Type versus Surgical Implication Matrix

Variant	Clinical Concern	Surgical Tip
Direct T2 origin	Incomplete sympathectomy if bypassed	Extend resection to include accessory branch at T2 level
Common trunk (T1–T2)	Misidentification as gray ramus	Trace trunk proximally and divide at both T1 and T2 levels
Dual branches	Partial denervation or residual sweating	Identify and divide both branches
Termination in stellate ganglion	Unexpected autonomic effects with stellate block	Visualize stellate ganglion region carefully
Slip into brachial plexus sheath	Risk of inadvertent nerve injury during plexus surgery	Retract plexus sheath and inspect for small sympathetic slips

Table 10 maps each major variant to its key clinical concern and recommended intraoperative strategy. Table 1 shows that the nerve of Kuntz was present in eighty percent of sides dissected. Table 2 demonstrates that most nerves originated directly from the second thoracic ganglion (sixty-two point five percent), with common trunk origins in twenty-five percent and dual-branch origins in twelve point five percent.

Table 3 reports a mean nerve length of three point eight centimeters (standard deviation zero point seven). Table 4 indicates a mean mid-point diameter of one point two millimeters (standard deviation zero point three). Table 5 reveals that seventy-five percent of nerves terminated in the brachial plexus sheath and twenty-five percent in the stellate ganglion. Table 6 shows that seventy-five percent of nerves crossed over the head of the second rib and twenty-five percent passed beneath it. Table 7 indicates that the nerve lay lateral to the subclavian artery in seventy-five percent of cases and medial in twenty-five percent. Table 8 confirms that bilateral symmetry of variants occurred in sixty percent of cadavers. Table 9 stratifies nerve presence by sex, showing presence in eighty-three percent of male sides and seventy-five percent of female sides. Table 10 links each variant type to its clinical concern and recommends that surgeons extend resection to include accessory branches at the second thoracic level trace common trunks proximally divide dual branches and inspect the brachial plexus sheath carefully to avoid incomplete sympathectomy or inadvertent nerve injury.

Discussion

The present study confirms that the nerve of Kuntz is a common anatomical variant in the North Indian population, identified in 80 percent of dissected sides. This prevalence aligns with prior reports ranging from 50 to 85 percent, underscoring the importance of routine consideration of this accessory sympathetic pathway during thoracic sympathectomy and related procedures [5]. The majority of origins arose directly from the second thoracic ganglion (62.5 percent), while one quarter emerged from a common T1–T2 trunk and a minority (12.5 percent) presented as dual branches. These findings suggest that surgeons encountering a single branch should remain vigilant for additional hidden fibers, particularly when operating at the T2 level [6].

The mean nerve length of 3.8 cm and diameter of 1.2 mm are critical parameters for intraoperative identification. In endoscopic sympathectomy, ports placed at the second rib must allow visualization of a structure of this size smaller than typical intercostal nerves to ensure complete division. The tendency of 75 percent of nerves to terminate within the brachial plexus sheath further highlights the risk of sparing fibers when only the stellate ganglion is targeted, explaining persistent palmar hyperhidrosis or vasomotor symptoms in some patients after standard approaches [7].

The course relative to the second rib head and subclavian artery also bears surgical relevance. With three quarters of nerves crossing over the rib head and lying lateral to the artery, an anterior approach requires careful dissection along the superior surface of the rib and just lateral to vessel pulsations [8]. Failure to inspect the medial aspect risks missing the 25 percent of variants that pass beneath the rib or medial to the artery. Bilateral symmetry in 60 percent of cadavers indicates that intraoperative findings on one side should prompt evaluation of the contralateral side for similar patterns [9].

Demographic analysis revealed a slightly higher presence in male specimens (83 percent) than females (75 percent), though the clinical implications of this difference are unclear. It may reflect sample variability rather than true sex-linked predisposition. Nonetheless, awareness of a high overall prevalence supports preoperative planning regardless of patient gender [10].

Our novel Variant Type versus Surgical Implication Matrix offers concrete strategies: extending resection margins to encompass accessory branches, tracing common trunks proximally, dividing all identified fibers, and systematically inspecting the brachial plexus sheath. These recommendations, if adopted, can reduce rates of incomplete sympathectomy and minimize inadvertent injury during plexus surgery [11].

Limitations include the modest sample size and use of formalin-fixed specimens, which may alter tissue pliability. Future work should correlate anatomic findings with in vivo imaging and clinical outcomes, and explore developmental factors that govern variant formation. Despite these limitations, our comprehensive morphologic data and practical guidance provide valuable insights to enhance the safety and efficacy of autonomic and plexus interventions in diverse patient populations.

Conclusion

The nerve of Kuntz is present in the majority of North Indian cadavers, most commonly originating from the second thoracic ganglion and traversing over the second rib head to terminate in the brachial plexus sheath. Its consistent length and diameter parameters support reliable intraoperative identification, yet its variable course—especially in relation to the rib head and subclavian artery—demands meticulous dissection techniques.

Recognizing the diverse origin patterns and termination sites is essential to achieve complete sympathectomy and to prevent inadvertent injury during brachial plexus procedures. The provided surgical matrix offers targeted strategies for identifying and managing each variant type. Incorporation of these findings into surgical practice and preoperative planning will improve outcomes in autonomic surgery and complex upper limb interventions.

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