

The Spinal Accessory Nerve Anatomy and its role in neck dissections; a review article

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ABSTRACT

Introduction: *The purpose of this literature review is to expand our existing knowledge to further understand the innervation of the trapezius muscle, so that new light can be shed which might aid in better outcomes in shoulder function after neck dissections.*

Methods: *A pub med review of the literature revealed 539 articles of which 15 were chosen*

Results: *Anatomic dissections using cadavers and intraoperative stimulation studies on live patients undergoing neck dissections are presented.*

Discussion: *The Spinal accessory nerve still remains the main nerve supply to the trapezius muscle. Several anatomical details of this nerve are presented. Although cervical plexus provides contributions they are not consistent. A majority of authors agree that during surgical dissections one should avoid removal of any nerve including the branches of the cervical plexus in order to achieve better functional outcomes, and to avoid the disabling shoulder syndrome.*

Key words: *Trapezius, Spinal Accessory nerve, Sternocleido mastoid, Neck dissections*

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INTRODUCTION

The spinal accessory, (SAN) or eleventh cranial nerve is composed of two distinct parts. (Fig 1). The Cranial part, or the accessory portion (ramus internus), is the smaller of the two, and is accessory to the vagus. It arises from the cells of nucleus ambiguus and the dorsal efferent nucleus and then emerges from the medulla below the roots of the vagus. It leaves the skull through the jugular foramen. The major portion of the eleventh nerve is the spinal portion (ramus externus). Several rootlets unite to form a single trunk, which enter the skull through the foramen magnum, where it joins the cranial portion of the nerve for a short distance. It leaves the skull, through the jugular foramen. Although it lies within the same dural sheath as the vagus nerve, it is separated from it by a fold of arachnoid. It descends in the neck behind or in front of the internal jugular vein and behind the digastric and stylohyoid to supply the sternocleidomastoid (SCM) and then descends to end in the deep surface of the trapezius. The trapezius is a large muscle consisting of 3 distinct parts: upper, middle and lower. Each part serves complementary, yet different roles. The simultaneous actions of the upper and lower parts exert a rotational

action of the scapula. This upward rotation of the scapula accompanies abduction of the arm at the glenohumeral joint and produces elevation of the arm above shoulder level.

Lesions of the SAN:

Unlike peripheral nerves, the cranial nerves lack collagen and epineurium. Because of this they are unable to stretch. This in turn makes them more vulnerable to injury. The accessory nerve can be damaged intracranially at the skull base, or in the jugular foramen or in the neck. Of these 71% are iatrogenic and 24% traumatic. The most common iatrogenic cause is the lymph node biopsy in the posterior triangle due to its superficial location. Other causes include neck dissections for the treatment of head and neck cancers, parotidectomy, carotid endarterectomy gunshot wounds etc. Other non-traumatic causes include Vernet's syndrome which is lesions of cranial nerves 9-11 with or without the involvement of 12, head injury, Herpes zoster, brachial neuritis and Schwannoma. Severance of the SAN is associated with the well-recognized shoulder syndrome. Loss of shoulder function due to resection of the SAN and denervation of the trapezius muscle is the most disturbing complication of Radical Neck Dissection(RND). The incidence of paralysis of this nerve has been reported as high as 63% in neck dissections. No relationship has been found between the incidence of neurologic dysfunction and adjuvant Radiotherapy.

Symptoms and signs of Paralysis:

Patients complain of dull aching discomfort, experienced along the upper margin of scapula, frequently described as resembling toothache. This pain is due to the stretching of scapula retractors (rhomboids) and the elevator (elevator scapulae), initiated by the unbalanced pull of the serratus anterior. In addition, arm abduction is limited to 90° with stiffness and weakness with overhead activity causing difficulties even with simple tasks such as combing one's hair.

Trapezius weakness causes downward displacement of the scapula with a downward and forward drop of the shoulder. With the abduction of the arm, scapular winging called lateral winging is seen, where in the inferior boarder of scapula is rotated away from the spine due to the unopposed action of the serratus anterior muscle. Eventually frozen shoulder may develop. Atrophy of the trapezius ensues. SCM muscle is usually unaffected unless the proximal portion of the nerve is cut.

Controversy existed in the literature very early on whether to sacrifice or spare the nerve in surgical neck dissections. Crile in 1906 advocated on sparing the nerve. In 1951 Martin advocated in removal of the nerve various modified radical neck (MRND) dissections have since evolved, attempting to salvage the nerve with varying inconsistent outcomes. These nerve sparing procedures have not been uniformly successful. Varying degrees of shoulder dysfunction, can be seen in spite of anatomic preservation of the SAN. It was postulated that the variability in functional outcomes could be due to additional innervation from the C², C³ and C⁴ branches.

We utilized the techniques of intraoperative electroneurography (Ref 1) in which the nerve function was measured by direct stimulation of the exposed nerve during surgery. Evoked potentials were measured to each part of the trapezius on stimulation of C², C³ and C⁴ nerves. Our study confirmed that the SAN provides the most important and consistent motor input to the trapezius muscle. There was also motor input from the C², C³ and C⁴ branches of the cervical plexus, but they were either not consistently present or when present, did not consistently innervate all 3 parts of the trapezius. Therefore, we could not confidentially conclude that in cases of modified neck dissections motor function can be supplemented by cervical plexus.

Almost 20 years have gone by since this article was published in Muscle and Nerve. The purpose of this article was to perform a literature review in an attempt to further expand our existing knowledge regarding the innervation of the trapezius muscle so that future modification in the operative techniques may be able to improve surgical outcomes.

METHODS

A literature search was performed using the key words SAN, neck dissections, and trapezius muscle. 539 articles were found from the database. Exclusion criteria included non-peer reviewed publications, not enough new information, irrelevant to the subject matter of interest, purely technical descriptions and articles prior to 1995 and non-English literature. 367 articles were too old, 51 were repeats, 14 were too technical. 13 were non English literature and 115 were irrelevant to the subject matter of interest. We chose 15, of which 7 were anatomic cadaveric dissections. 6 were live neck dissections. Two were retrospective literature reviews.

In This review we will present the findings, and summarize the data. A description of the study population, number of subjects, and anatomical descriptions are summarized in table 1

DISCUSSION

Anatomical aspects of the Spinal Accessory nerve:

The origin of the nerve is indisputably from the spinal cord without major contribution from the medulla. Just as there is extensive anastomosis between the Trigeminal, Fascial and Vestibulo-cochlear nerves there is also extensive anastomosis between glossopharyngeal, vagus and SAN. (Ref 3). Also extensive but variable neural anastomoses exist between the lower cranial nerves and the upper cranial nerves so that collective term of cervical plexus has been used.

Ryan et al (Ref 2) traced these nerves from their rootlets, attaching to the spinal cord and the medulla and then through the jugular foramen. They found 3 types of innervation of the SCM muscle: Type A non-penetrating, type B partially penetrating, type C completely penetrating types. In addition, they also found 5 types of innervation of the trapezius muscle by the main trunk and branches of the SAN. They concluded that dysfunction can be avoided by paying attention to all of these branches.

In five of the 20 cadaveric dissections, Dailiana et al (Ref 4), found branches from the cervical plexus. However they did not feel that the quality and quantity of motor input from these branches will be able to substitute for the SAN loss during neck dissections. During 74 hemi neck dissections Lanisnik et al (Ref 6) identified 3 patterns of innervation from SAN to the trapezius. Type 1 exists at the posterior end of SCM. Type 2 the nerve to Trapezius branches off before entering SCM and in Type 3 the nerve exists at the posterior part of SCM. This description of these 3 patterns might be helpful in identification of the nerve during MRND.

Shiozaki Kuzumari (Ref 5) conducted anatomical dissections on 35 cadavers using the superficial cervical vein, a branch of the external jugular vein as a landmark, identified 3 types of

innervation for SCM muscle. Type A the not-penetrating was seen in 45.9%, Type B partially penetrating in 50.8 % of cases, and Type C the completely penetrating type of SAN in 3.3%. As far as the Trapezius was concerned 4 different branching types of SAN was found. Of which type 1 was seen in 50%. Type 2 in 26.9%. Type 3 in 11.5% and type 4 in 7.9%. They recommend that these potential individual differences in the innervation of SAN of SCM and Trapezius should be considered for better outcomes.

Liu (Ref 12) studied 34 cadavers and concluded that the internal and external branches of the SAN are not as clearly defined as previously thought. The notion that the internal branch is cranial and external branch is spinal is not entirely true, rather these branches have various combinations of cranial, spinal roots and connections to vagus nerve.

Kierner et al. (Ref 13) utilized intraoperative EMG during 17 MRND patients and identified a distinct branch to the descending part of the trapezius from the SAN in the posterior triangle of the neck. They concluded that attention should be paid to this branch to prevent potential shoulder disability

Cervical plexus contributions: The following authors further elaborated on the subject of cervical plexus contributions to the trapezius. Restrepo (Ref 7) retrospectively studied 41 patients who underwent neck dissections and found an unrecognized sign that is, sub clavicular pectoral asymmetry due to SAN lesion and suggested the reason for this is due to possible disruption of the connections of the SAN to cervical plexus via the supra clavicular nerve.

Yin Pu et al. (Ref 8) studied 34 patients undergoing RND and identified branches from C² & C⁴. They recorded with EMG conventional systems by needle electrodes from all 3 parts of the trapezius muscle. Potentials were recorded under 3 circumstances: a) intact SAN b) section of superior part of communication between nerve and cervical branches and c) complete section of the nerve. They saw contractions from C³, & C⁴. They concluded that the accessory nerve provides the main motor input to the muscle, but preservation of C² & C⁴ branches during MRND should improve function.

Tubbs et al. (Ref 9) further identified and classified cervical nerve innervation. Fibers derived from C² and C⁴ were classified as type I innervation. C² and C³ were classified as type II, C³ and C⁴ as type III. Immunohistochemical analysis confirmed presence of motor axons in all these branches. They also concluded that even though cervical nerves innervate the trapezius with motor branches, the degree to which they innervate is not completely understood.

Kim et al (Ref 10) studied 24 patients who had RND for cancer with metastasis to the lymph nodes. After preserving the SAN and all cervical branches, they stimulated them electrically. Action potentials were recorded. They also reached similar conclusions that the SAN innervates the trapezius muscle 100% of time. Motor innervation was observed from C⁴ more than C³ more than C². Cervical contributions were inconsistently present and when present did not consistently innervate all 3 parts of the muscle.

Zhao et al (Ref 11) studied 18 adult male Sprague-dawley rats and concluded that the SAN supplies the most important input to the trapezius muscle. Motor innervations from the cervical plexus are not very significant. Soo et al. in 1996 (Ref 14) demonstrated that 61% of necks showed evidence of motor innervation and motor axons in the branches of the cervical plexus, mainly C³ & C⁴. They suggested that if RND must be carried out, the cut ends of the SAN should be cable grafted to C³ which has the highest chance of being a motor nerve.

Lloyd (Ref 15) provided an excellent review of the accessory nerve and concluded that the path of the nerve in the neck is very variable and there is no reliable landmark for its identification. Shoja (Ref 3) in a literature review found extensive neural anastomoses between lower and upper cranial nerves aptly called plexus.

Stacey (Ref 16) established that there is motor supply from C² and C⁴ ventral roots to trapezius.

Limitations: The availability of literature was limited. Not enough evidence was available to contradict or supplement the already existing knowledge.

CONCLUSIONS

The literature review further confirms our previous findings that the Spinal Accessory nerve is the main motor supply to the trapezius muscle. Although several motor contributions from the cervical plexus mainly C², 3 and 4 exist, these contributions are neither consistent nor significant enough to substitute for SAN function. Complex anastomoses do exist between the cervical nerves and lower cranial nerves. Novel descriptions and further details of branching patterns of the SAN have been discussed by a few authors. It's the opinion of the majority of authors that a serious effort should be made to identify all these branches and different patterns of innervation. Preservation and identification of these branches may result in better post-operative functional outcomes.

Summary of Findings

Author	Type of Study	Methods	Results
Shiozaki	Anatomical dissection	35 cadavers	3 types of innervation to SCM 5 types innervation to trapezius
Pu	Electroneurography and histochemical staining	34 RND	SAN is the main innervation of trapezius Cervical contributions inconsistent or incomplete
Wen Zhao	Animal study		Motor innervation is consistent by SAN. Cervical contributions unreliable
Tubbs	Anatomical study	15 cadavers	There are contributions from cervical nerves, but to what degree is uncertain
Kim	Prospective study	EMG/NCV Intraoperative 24 patients	SAN is most consistent C2,C3,C4 although present inconsistent or irregular
Lanisnik	Anatomic study	20 dissections	SAN is most vulnerable at IIa & IIb positions
Lloyd	Systematic review		Provided several methods for identification of SAN to avoid injury.
Ryan	Anatomic study	Cadaveric dissections	Cranial and cervical roots re explored, found connection between vagus& SAN Identified 3 types of innervation for SCM and 5 types for Trapezius
Shoja	Literature review		Extensive neural anastomoses found between lower and upper cranial nerves. Together they should be called plexus
Soo k	Neck dissections	EMG & NCV	61% had motor contribution through cervical plexus
Kierner	Intraoperative	17 MRND	A distinct branch is identified from SAN to trapezius
Liu	Anatomic study	Cadaver dissections	Identified many branches from cranial, spinal roots and vagus.
R.J Stacey	Anatomic study	32 Cadaver dissections	Direct motor supply from the cervical plexus c2 and c4 ventral roots to the Trapezius.
Restrepo	Retrospective clinical study	41 patients who had neck dissections	Possible connections of SAN to cervical plexus via supra clavicular nerve.
Dailiana	Anatomic study	20 cadaveric dissections	SAN is most vulnerable after leaving SCM, Direct innervation of Trapezius by cervical plexus seen. Neuratization of SAN should be done distal to these branches.

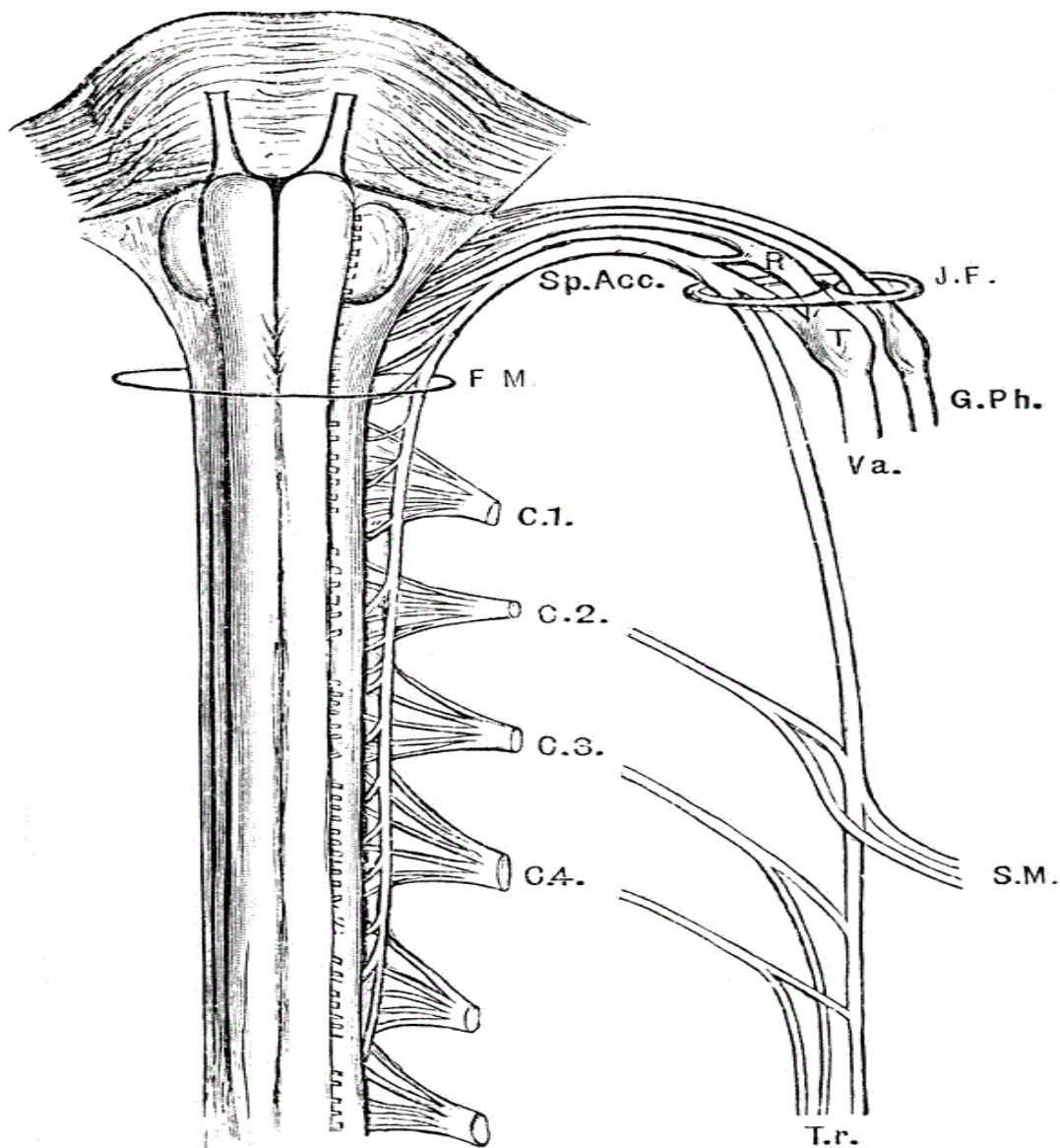
Fig 1: Anatomy of the Spinal accessory nerve

Sp.Acc; spinal accessory Nerve, J.F Jugular Foramen, G.Ph Glossopharyngeal Nerve

F.M foramen magnum C.1 Cranial nerve one C.2 Cranial nerve Two C.3 Cranial nerve three C.4 Cranial nerve four S.M Sternocleido mastoid muscle, T.M Trapezius Muscle, Va- vagus, R, ganglion of the root; T, ganglion of the trunk

Source; Cunningham, D.J. *Textbook of Anatomy* (New York, NY: William Wood and Co., 1903)

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**Figure 1. Spinal accessory nerve anatomy**

C1, C2, C3, C4 - C\cranial nerves 1 to 4

Tr - branch to trapezius

SM - branch to sternocleidomastoid

JF - jugular foramen

Va - vagus nerve

G Ph - glossopharyngeal nerve

Sp Acc - spinal accessory nerve

F M - foramen magnum

R - ganglion of the root

T - ganglion of the trunk

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