



Variations in the Anatomy of Spinal Accessory Nerve and its Landmarks for Identification in Neck Dissection: A Clinical Study

Venkatesh Anehosur¹ · Kaustubh Kulkarni² · Niranjana Kumar³

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Abstract

Purpose To assess the anatomy of the spinal accessory nerve (SAN), its variations and the landmark of level II B lymph nodes.

Methods Prospective study included 50 patients from 2016 to 2018. The predictor variables were drawn from demographic details of the patients; SAN was analyzed intraoperatively with the parameters like the nerve relationship with the IJV, SCM muscle, contributions of cervical plexus and a new parameter of length from midpoint of clavicle to entry of nerve in the trapezius muscle in the lower part of neck which was studied for the first time and forms the prime identification landmark to preserve the nerve. Outcome variables were details of anatomic variations and branches and utility of these landmarks in prevention of nerve injury.

Results Sample consisted of 38 (76%) male and 12 (24%) female patients. The SAN with respect to the IJV was

dorsal in 42% patients and ventral in 58%. In 54% cases, SAN gave a branch to the SCM without penetrating the muscle and in 46% gave a branch to the SCM penetrating the muscle. SAN received contributions from the C2 root of the cervical plexus in 68%, both C2 and C3 in 54% and C3 in 50% cases. Mean length from measurements recorded between mid-line of clavicle to insertion of SAN to trapezius muscle and entry of SAN into trapezius muscle was 59 mm with variations recorded in gender and short/long neck.

Conclusion The result of this study suggests that parameters used are simple clinical tools for identification of the SAN and its variations resulting in no nerve injury. It is prudent for the surgeon to have knowledge of sound anatomical landmarks with the variations in the SAN course which avoids morbidity and improves the quality of life.

Keywords Oral cancer · Head and neck surgery · Neck dissection · Level II b lymph nodes

✉ Venkatesh Anehosur
venkyrao12@yahoo.co.in

Kaustubh Kulkarni
kulkarni_kaustubh@yahoo.com

Niranjana Kumar
drniranjanakumar@sdmmedical.org

- ¹ SDM Craniofacial Unit, SDM College of Dental Sciences and Hospital, A Constituent Unit of Shri Dharmasthala Manjunatheshwara University, Dharwad, Karnataka, India
- ² Department of Oral and Maxillofacial Surgery, Bharati Vidyapeeth (Deemed To Be University) Dental College and Hospital, Pune, India
- ³ Department of Plastic Surgery, SDM College of Medical Sciences and Hospital, A Constituent Unit of Shri Dharmasthala Manjunatheshwara University, Dharwad, Karnataka, India

Introduction

Neck dissection (ND) has greatly evolved over the years ever since its first description by Dr. George Crile in 1906 and still remains the gold standard in head and neck cancer management. ND initially involved the excision of vital structures as those of sternocleidomastoid (SCM) muscle, the spinal accessory nerve (SAN) and internal jugular vein (IJV), along with all the cervical nodes present. Functional ND was first reported by Osvaldo Suarez in the year 1963 [4, 7] and over the past 50 years has had a sequential development in preservation techniques of these vital structures. Selective ND, based on the lymph drainage

patterns of particular sub sites is a further development [1, 2, 20].

The conservative procedures have ensured that oncological safety is not compromised and have also ensured alleviation of neck and shoulder morbidity. Postoperative morbidity to the shoulder and pain in the shoulder and neck after neck dissection is a common complication and closely affects the quality of life (QOL) of patients treated surgically for head and neck cancer. Disturbance to the function of shoulder and its movements is also one of the disabling consequences for patients and is related primarily to the accidental injury to the SAN.

The SAN exits the base of the cranium via the jugular foramen. The SAN then reaches the superior border of the SCM muscle by coursing in an inferior and posterior direction. It then enters the posterior triangle by running further inferiorly either deep to or through the SCM muscle giving innervations to the SCM muscle. Crossing the posterior triangle in an oblique inferior path, within the investing layer of cervical fascia, the SAN reaches the anterior border of trapezius muscle innervating it. In the posterior triangle, the SAN is susceptible to injury because it is located superficially.

Sacrificing the SAN during NDs is reported to cause shoulder morbidity and the classical shoulder syndrome which is characterized by restriction of shoulder movements and pain in the shoulder and neck; preservation of the SAN minimizes this and avoids the shoulder syndrome [5, 16]. The SAN divides the Level II lymph nodes into levels IIa and IIb by crossing obliquely in a superoinferior and mediolateral direction [10, 11, 18].

The SAN has various courses and relations, and previous studies have focused on the analysis of its course in the neck by considering the relations with innervations of trapezius and sternocleidomastoid muscles. There is no literature about variations in anatomy of the nerve. With the increasing use of selective and super-selective ND, a detailed knowledge of the anatomy and course of the SAN is needed so as to avoid accidental injury to the nerve and to try to preserve it. This is the first clinical study of its kind in the Indian Subcontinent where the landmarks recorded are simple and easy for surgeons in this field [17].

Methodology

Proposed prospective study involved 50 cases of oral squamous cell carcinoma during 2016–2018. Ethical clearance was obtained from the Ethical committee of the institute (IRB number-2016/P/OS/40). All the patients included in the study were biopsy proven cases of OSSC between 30 and 70 years of age indicated for neck dissection. No neo-adjuvantive chemotherapy and/or

radiotherapy was rendered to the patients. Patients with loco regional failure, metastatic LN's larger than 3 cm in the level II group, presence of extra capsular spread or those who had an indefinite SAN relationship with adjacent structures were excluded from the study. All the surgeries were performed by a single surgeon. The patients included in the study were surgically treated with wide excision of the lesion and modified radical neck dissection sparing the IJV and SAN (as per classification proposed by American society for head and neck surgery and its council and American academy of otolaryngology-head and neck surgery, 2002 {JAMA Network}) [17]. The parameters assessed were:

1. The relationship of SAN to the IJV—passing dorsally, ventrally, or through the vein.
2. Relationship of the SAN to the SCM muscle—non-penetrating branch or a penetrating branch to the muscle.
3. Contributions from cervical plexus to the SAN—from C2 root, from both C2 and C3, or from C3 root.
4. Relationship with trapezius muscle—length between midpoint of clavicle and entry of spinal accessory nerve into trapezius muscle superiorly (in mm).

The data were analyzed using appropriate statistical analysis such as Chi-square test, Wilcoxon matched pairs test, unpaired *t* test, paired *t* test.

Results

Out of 52 patients operated during this period, 50 were included in the study and 2 were excluded for lack of communication and recording during surgery. Mean age of patients was 51.92 and a male:female ratio of 3.1:1. The SAN relation to the IJV was noted dorsal in 21 (42%) cases (Fig. 1) and ventral in 29 (58%) cases (Fig. 2). The SAN coursed along the SCM muscle. In 27/50 cases (54%), the SAN gave a branch to the SCM without penetrating the muscle. In 23/50 cases (46%), the SAN gave a branch to the SCM that penetrated the muscle. The cervical plexus contributions to the SAN were from multiple roots and in combination of these. The C2 root of the cervical plexus gave a branch to the SAN in 34 cases (68%) (Fig. 3), both C2 and C3 roots together in 25 cases (50%), and C3 root in 27 cases (54%). The mean length between midline of clavicle and attachment of trapezius muscle and entry of SAN into trapezius muscle was 59 mm (Fig. 4). Comparative analysis of male and females with mean length between midline of clavicle and point of entry of SAN into the trapezius muscle was suggestive that the mean length was marginally greater in males (59.21 mm) as compared to females (58.58 mm). Comparison of the relationship of



Fig. 1 Dorsal variant of the SAN in relation to the IJV crossing from medial aspect of IJV to lateral aspect

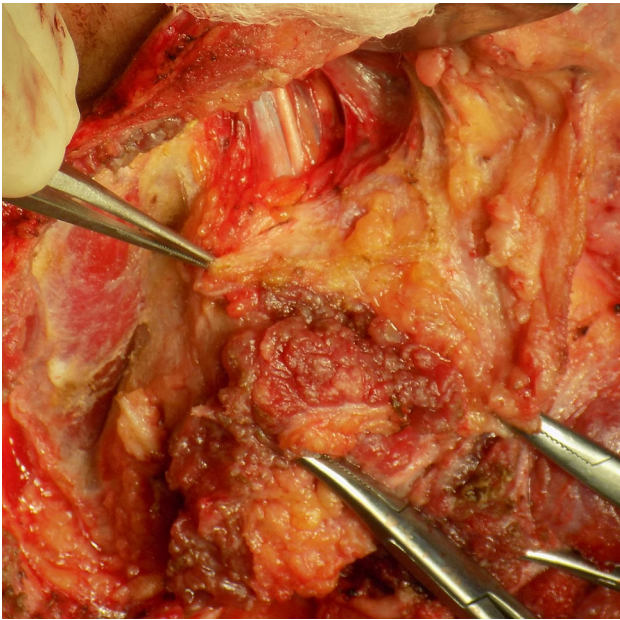


Fig. 2 Ventral variant of the SAN in relation to the IJV passing inferiorly to the IJV

SAN to SCM muscle and relationship of SAN to IJV suggested that in the dorsal variety the nerve usually gives off a branch with penetration to the SCM muscle, whereas when the nerve is present ventrally, a non-penetrating branch to the SCM is present.

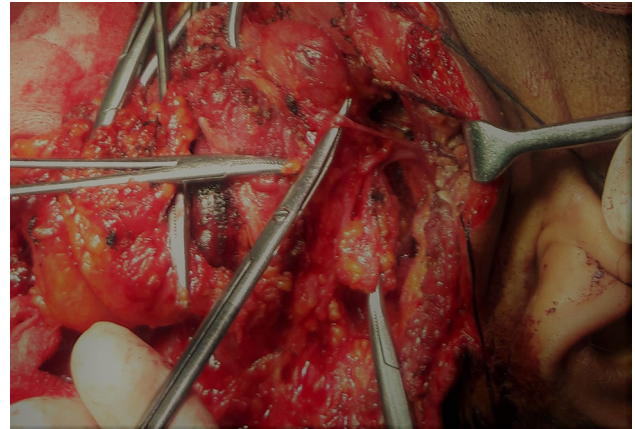


Fig. 3 C2 contribution of the cervical plexus and relation to the SAN

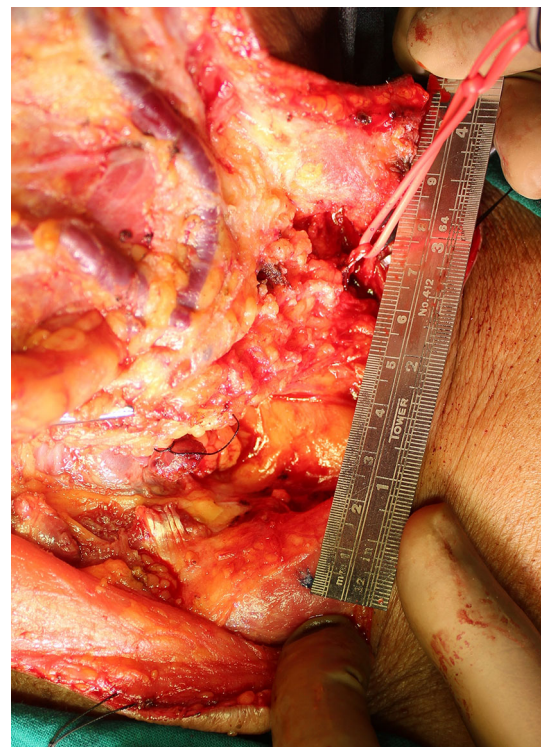


Fig. 4 Measurement of the length between the midpoint of clavicle and point of entry of SAN into the trapezius muscle (blue point marking corresponds to midpoint of clavicle)

Discussions

Neck dissection (ND) has greatly evolved over the years ever since its first description by Dr. George Crile in 1906 and still remains the gold standard in head and neck cancer management [4]. The conservative procedures have ensured that oncological safety is not compromised and have also ensured alleviation of neck and shoulder morbidity. Postoperative morbidity to the shoulder and pain in the shoulder and neck after neck dissection is a common

complication in patients treated surgically for head and neck cancer. The injury to the SAN that may be caused inadvertently during surgery leads to postoperative functional loss, temporarily at least, in the range and dexterity of the shoulder joint movement and can be debilitating for the patient. Thus, identification and retention of the SAN would be of utmost priority, especially when achieving oncological clearance remains unaffected.

Shoulder complaints were present in almost 22% of the selective NDs [12, 16, 19] (it is to be noted here that modified/selective NDs evolved with the very aim of preserving the SAN and reduce the ill effects of SAN injury). Traction, neuropraxia secondary to the handling of the nerve, and skeletonization were suggested causes for the same. Hence, with the increase in the use of selective and supers elective neck dissections, a comprehensive knowledge of the course and anatomy of the SAN and its relations with the adjoining structures is of prime importance to a surgeon to avoid accidental injury and to avoid these postoperative complications.

Various methods of identification of the SAN include the intra operatively at the Erb's point, the point where the SAN leaves the posterior triangle with relation to the trapezius muscle and at the differentiation point of levels II A and II B lymph nodes in the upper neck. Other methods include identification by the use of nerve detectors (TENS) at these anatomical landmarks [6, 8, 11, 13].

Most of the patients of OSCC presented in locally advanced stages. In 70–80% of patients of OSSC, the site of involvement was found to be the Buccal Mucosa. These cancers have a high affinity for the buccal mucosa due to the indiscriminate use of tobacco and usually present at an advanced stage of the disease. Lack of awareness, low socioeconomic status, lack of health-care facilities, and scarcity of trained medical and social workers may be the cause for the late/advanced stage presentation [2, 4, 7, 12, 16, 20]. Our study included 50 patients, all diagnosed cases of SCC of the oral cavity, in the age groups of 30–70 years with a mean age of 51.92. Out of the 50 subjects, 38 were male (76%) and 12 (24%) patients were female with a ratio of 3.1:1. The incidence of various subsites of the lesions was found to be 32 patients (64%) SCC of Buccal mucosa, Gingivobuccal sulcus, and retromolar trigone; 14 patients (28%) SCC of the lateral border of tongue and 4 patients (8%) were SCC of alveolous.

The SAN exits the base of the cranium via the jugular foramen. The SAN then reaches the superior border of the SCM muscle by coursing in an inferior and posterior direction. It then enters the posterior triangle by running further inferiorly either deep to or through the SCM muscle giving innervations to the SCM muscle. Crossing the posterior triangle in an oblique inferior path, within the investing layer of cervical fascia, the SAN reaches the

anterior border of trapezius muscle innervating it. Kierner et al. [11] in their cadaveric study suggested the SAN in relationship to the IJV was coursing dorsally in 44% and ventrally in 56% cases. Hollingshed [10] reported that in relation to the IJV the SAN courses, that the ventral relationship of the SAN is more common as compared to the dorsal variant. Although there might be variations in cadaveric studies and in vivo studies, in this study, the SAN passed dorsally in 42% (21/50 cases) and ventrally in 58% (29/50 cases) of the cases which was consistent with the previously published literature. The literature suggests that a rare variant of the SAN is that the nerve passes through the IJV, but in our study none of the cases had this variant, and hence, it can be suggestive of a very rare possibility.

Analysis of the contributions of the cervical plexus to the SAN was found primarily from the C2, C3, and a combination of the two and has communication to the nerve deep to the SCM muscle in the posterior triangle [3, 9, 14, 15, 21]. There were multiple contributions from these roots of the cervical plexus in the subjects. In our study, we found that contributions from the C2 root alone of the cervical plexus to the SAN in 34 cases (68%), both C2 and C3 roots together in 25 cases (50%), and C3 root only in 27 cases (54%) were found to be consistent with the previous studies.

Three types of innervations to the SCM muscle have been reported by Shiozaki et al. [18]. These have been classified as type A—non-penetrating type, type B—partially penetrating type, and type C—completely penetrating type. In the same study, series type A nonpenetrating innervations of SCM Muscle were reported in 43.1%, while the rest 53.9% had types B and/or type. Kierner et al. report 29% as non-penetrating type versus 71% penetrating variants. The SAN is also suggested to take an S-shaped 3-dimensional course if the SAN passes through the SCM [11]. In our study we found that in 27 cases (54%) the SAN had a branch without penetration to the SCM muscle, whereas in 23 cases (46%) there was a branch with penetration to the SCM muscle.

Kierner et al. [11] suggested that the SAN in relationship to the trapezius muscle gave one branch in 9% of the cases, two in 61% cases, and three in 30% cases. An additional branch could be found in most of the cases approximately about 2 cm to the medial aspect of the trapezius muscle and can be found 2–3 cm cranial to the main trunk of the SAN. In this study, we attempted to calculate the distance from the midpoint of the clavicle to the point of entry of the SAN into the trapezius muscle and found that the maximum distance was 71 mm and minimum was 48 mm. The mean distance was 59 mm with a standard deviation of 6.29. This is an important landmark for tracing the SAN from the lower neck and dissecting

superiorly. The SAN innervated all parts of the trapezius muscle, and hence, the isolation and preservation of the nerve become important.

Comparative analysis of males and females with mean length between midline of clavicle and point of entry of SAN into the trapezius muscle was suggestive that the mean length was marginally greater in males (59.21 mm) as compared to females (58.58 mm). This might be a result of the length of the neck being longer in males as compared to females. (*t*-value 0.2985) (*p*-value 0.7666). This factor was not statically significant, but the fact that the parameter has not been studied before; it might help the surgeon with the ease of identifying the SAN and dissecting through the superior direction.

Comparison of the relationship of SAN to SCM muscle and relationship of SAN to IJV suggested that in the dorsal variety the nerve usually gives off a branch with penetration to the SCM muscle, whereas when the nerve is present ventrally, a branch without penetration to the SCM is usually present and this was statistically significant.

The lymph nodal area bordered deeply by the fascia overlying the splenius capitis and levator scapulae muscles, anteriorly and inferiorly by a plane at the level of the SAN, superolaterally by the inferior border of the posterior belly of the digastrics muscle, superiorly by the skull base, and posterolaterally by the SCM (Fig. 5) is the region of the Level IIB LN. The risk of metastasis to this group is greater for tumors arising in the oropharynx, nasopharynx, and scalp of the occipital area. Studies show that the position of SAN is responsible for the inferior and anterior border of level IIB lymph nodes. If the nerve is present ventrally, level IIB will cover a wider area making it difficult to

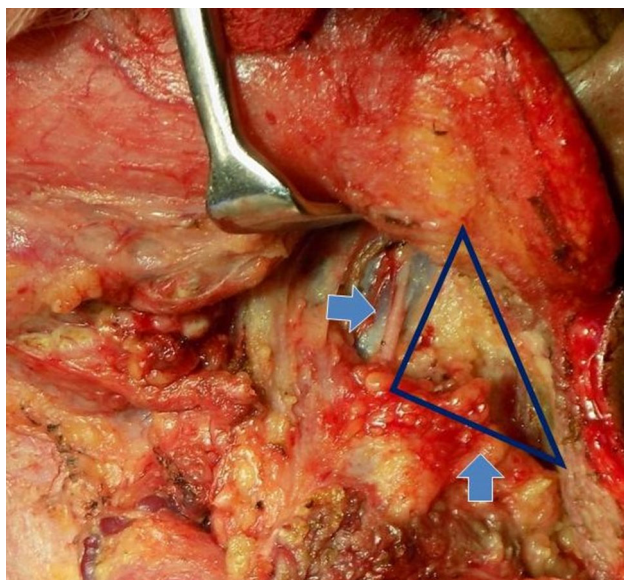


Fig. 5 Differentiation of level IIA and II B lymph nodes by SAN (triangular area—level IIB lymph nodes)

completely excise the nodes. This increases the chances of accidental injury to the nerve while clearing this group of LNs. In this study, SAN coursed ventrally in greater number of cases. The number of level II b LNs was found to be greater in cases where the SAN passed ventrally than in the case of a dorsal course of the SAN. Surgeons should be conscious about these variations in the anatomy of the SAN and its implication on level IIB lymph nodes in order to prevent postoperative complications and provide oncological clearance (Fig. 6).

To summarize the study, the importance of the preservation of the SAN is well documented. It is also prudent to understand that the SAN has a diverse anatomy. Identification of the variations in the anatomy of the SAN helps in the prevention of accidental injury to the nerve, thus decreasing the postoperative complications as those of pain and frozen shoulder, and improves the quality of life by maintaining the hand and shoulder function. In our prospective study on 50 NDs, we found that the SAN in relation to the IJV was dorsal in 21 cases (42%) and ventral in 29 cases (58%). In relation to the SCM muscle, the SAN gave a penetrating branch in 23 cases (43%) and did not give a penetrating branch in 27 cases (54%). The SAN was noted to receive contributions from C2 root alone in 34 cases (68%) from both C2 and C3 in 25 cases (50%), and C3 only in 27 cases (54%). The maximum distance between midline of clavicle and attachment of trapezius muscle and entry of SAN into trapezius muscle was found

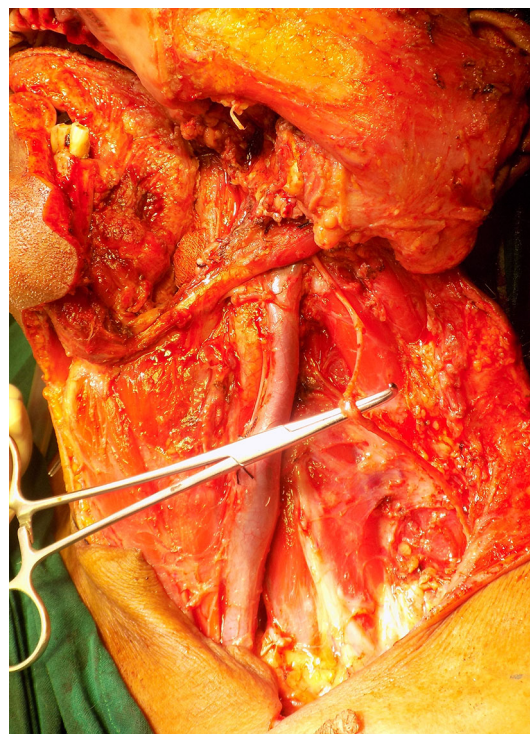


Fig. 6 Complete isolation of the SAN

to be 71 mm and minimum was 48 mm and mean distance was 59 mm. Surgeons should be conscious about these variations.

Conclusion

Even though there are no documented studies for these comparisons, these findings will help surgeons to identify the nerve emphatically and dissect around with predictable identification of variations thus avoiding injury to the nerve and resultant shoulder dysfunction.

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Declarations

Conflict of interest The author declare that they have no conflict of interest.

Ethical approval Approved (IRB number-2016/P/OS/40), and informed consent was obtained from patients.

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