BJHS
Birat Journal of Health Sciences

ISSN:

2542-2758 (Print) 2542-2804 (Online)

ARTICLE INFO:

Received Date: 23 December, 2024
Accepted Date: 29 April, 2025
Published Date: 31 August,2025

KEYWORDS:

Accessory Nerve; Neck Dissection; Jugular Foramina; Vagus Nerve.

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Access the article online

DOI: 10.62065/bjhs659

CITATION:

Mulmi RG, Sah BP, Thapa Chhetri S, Paudel D, Mishra S, Neupane D. Anatomic Relationship Between the Spinal Accessory Nerve and Internal Jugular Vein in the Upper Neck during Neck Dissection: An Observational Study. 2025; 10 (2): 29-35.

Anatomic Relationship Between the Spinal Accessory Nerve and Internal Jugular Vein in the Upper Neck during Neck Dissection: An Observational Study

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ABSTRACT

Introduction: Spinal accessory nerve (SAN) is the eleventh cranial nerve. SAN exits the jugular foramen with ninth and tenth cranial nerves as well as the internal jugular vein (IJV). The nerve can pass lateral, medial or directly through IJV.
Objectives: To find the intraoperative relationship between the SAN and IJV in the upper neck, at the level of superior border of posterior belly of digastric (PBD) muscle.

Methodology: A cross sectional observational study was carried out in Department of Otorhinolaryngology and Head & Neck Surgery, BP Koirala Institute of Health Sciences, Dharan from December 2019 to November 2020. The study population involved all the patients who were scheduled for unilateral or bilateral level II neck dissection and procedure where SAN and IJV relationship could be assessed. The intra operative anatomical relationship findings of each side operated were recorded and statistically analyzed.

Results: The study enrolled 39 patients who met the inclusion criteria. Mean age of the patient was 49.59 ± 12.57 years. Unilateral and bilateral neck dissections were done for 31 (79.48%) and 8 (20.51%) cases respectively. Therefore, considering each side as a case, the total number of cases were 47. The SAN was positioned lateral to, medial to and directly through IJV in 35 (74.46%), 9 (19.14%) and 3 cases (6.38%) at superior border of PBD muscle.

Conclusion: PBD muscle is the most common location at which the SAN is encountered. The majority of SANs course lateral to IJV at the level of PBD muscle. Iatrogenic injury to the SAN can be minimized considering this anatomical relationship during neck surgeries.

Introduction

The eleventh cranial nerve is the spinal accessory nerve (SAN). There are two roots of accessory nerve- cranial part and spinal part. The cranial part arises from the nucleus ambiguous and also from the dorsal nucleus of the vagus nerve.[1] The spinal roots arise from the spinal nucleus found in the ventral grey column extending down to the first five cervical vertebral levels. These fibers then emerge from the spinal cord and then ascend lateral to the spinal cord through the foramen magnum. After that, it travels to the JF, where the cranial root gives it some fibres. Together with the internal jugular vein (IJV) and the ninth and tenth cranial nerves, the SAN leaves the JF.[2-4] It then courses inferiorly passing medial to the styloid process and also found medial to the posterior belly of the digastric (PBD) muscle.[1] The nerve travels for a distance of 3 to 4 cm on the levator scapulae, then penetrates the[5] deep surface of the sternocleidomastoid (SCM)

muscle. The SCM muscle that it innervates receives branches.5

According to an observational study performed by Richard W. Nason et. al on "The Anatomy of the Accessory Nerve and Cervical Lymph Node Biopsy" the useful anatomical landmarks to identify SAN were the proximal IJV in the anterior triangle and Erb's point in the posterior triangle. The proximal IJV lies immediately anterior to transverse process of the atlas and is the key to identifying the proximal course of the accessory nerve (Figure 2). The SAN runs from the JF to the anterior border of trapezius. It is vulnerable to injury in surgical procedures involving either the anterior or the posterior cervical triangles (Figure 3). 5

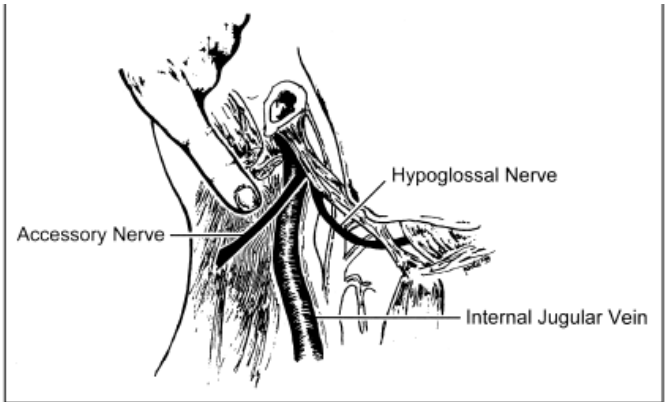

Figure 2: Identification of the accessory nerve in the anterior triangle using the proximal internal jugular vein as a landmark. The index finger is on the transverse process of C[15]

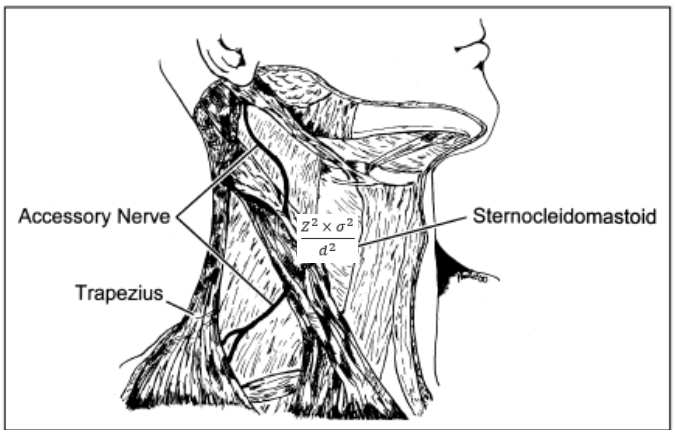

Figure 3: The spinal accessory nerve showing its course in the anterior and posterior triangle[5]

The management of metastatic nodal disease in head and neck cancer has greatly benifited by neck dissection (ND), which George Crile initially reported in 1906.[6-8] Radical neck dissections (RND) involve the sacrifice of the SAN and result in restricted shoulder abduction and postoperative pain.[9] Functional neck dissection (FND) was introduced with the preservation of IJV and/or SAN in 1963.[10] Modified radical neck dissections (MRND) and selective neck dissections (SND) have emerged which intended to minimize dysfunction by preserving the SAN without compromising oncologic results. Moreover, a SND often aims to further reduce risk to the SAN by avoiding a level V dissection altogether.[11,12] An injury at the level II region is most likely the cause of shoulder dysfunction when there is no level V dissection.[13] The anterior border of the SCM is typically where the SAN is typically commonly identified in a level II neck dissection. After that, it is skeletonised anterosuperiorly[14] and proceeded deep to the PBD muscle, where the damage is most likely to happen. The risk of injury may be minimized with a thorough understanding of the SAN anatomy and its relationship with the IJV.

Specifically, the nerve can pass lateral (superficial) or medial (deep) to the IJV, or it can pass directly through it as anatomical variations.[11,15,16] Thus, this variability between the SAN and the IJV is widely accepted in the published literature and anatomy textbooks.[15,16] Therefore, the objective of study was to evaluate the SAN's course in relation to the IJV at the upper border of PBD muscle during surgery in order to ascertain how frequently it occurs at each of the three possible positions.[11] These relations and positions are, however, not studied in the Nepalese population yet. Knowledge of these variations is important in locating the SAN and avoiding its inadvertent injury during neck procedures such as node biopsies, SAN blocks, and radical neck surgeries[17,18] to avoid the morbidity associated with SAN injury.

Methodology

This is a cross sectional observational study done in the Department of Otorhinolayngology-Head and Neck Surgery, BP Koirala Institute of Health Sciences, Dharan, Nepal. The study duration was from December 2019 to November 2020. The study was reviewed and approved by Institutional Review Committee of the Institute.

The study population involved all the patients who were scheduled for unilateral or bilateral level II neck dissection for head and neck pathology and/or procedure where the relationship between SAN and IJV could be assessed and those who consented to surgery. The patients undergoing neck dissection not involving level II, patients undergoing revision surgery, and when intraoperative location of the SAN at the level of the digastric muscle could not be ascertained were excluded from the study. All the cases fulfilling the inclusion criteria were included in the study. Non-probability convenient sampling was done and all the consecutive samples were included.

This study considered 95% CI and 80% power to estimate sample size. A total of 39 patients were enrolled in the study. The patients diagnosed with head and neck pathology in Department of Otorhinolayngology Head and Neck Surgery and scheduled for unilateral or bilateral level II neck dissection and/or procedure where the relationship between SAN and IJV could be assessed, were well explained about the study, taken informed consent and included in the study.

During intra-operative period, the anatomical relationship between SAN and IJV at the level of superior border of posterior belly of digastric as found by the main surgeon in each operation in each side were recorded in predesigned proforma. The findings were categorized into Group A, B and C for SAN lateral(superficial/ventral) to IJV, SAN medial(deep/dorsal) to IJV and SAN passing directly through IJV respectively.

The collected data were entered in the Microsoft Excel file. Data were analyzed using SPSS (Statistical Package for the Social Sciences) Version 20 for Windows Software. Descriptive statistics and frequencies were determined for categorical and numerical variables. Frequency, percentage, mean, and standard deviation were calculated.

Results

The findings from a total of 39 patients who underwent neck surgeries were recorded in this study. The mean age of patient was 49.59 years with SD of ±12.57 years. The age of the patients ranged from 17 to 70 years of age. The most common age group was 46 to 60 years (46.16%) followed by 31 to 45 years (25.64%) as shown in Table 1. Among 39 patients, 32 (82.05%) were male and 7 (17.94%) were female.

Table 1: Distribution of age groups

Age Category (years)	Frequency	Percentage	Mean +/- SD
Under 30	4	10.25	49.59 +/- 12.57
31-45	10	25.64	
46-60	18	46.16	
61 and over	7	17.94	
Total	39	100	

Among 39 neck surgeries carried out for different head and neck pathologies, majority of cases consisted of Neck Dissections done for oncological diagnosis and treatment i.e. 29 cases (74.35%). And, remainder of cases were neck surgeries done for various other pathologies including, 4 (10.25%) cases for branchial cysts, 4 (10.25%) cases for parotid neoplasms and 2 (5.12%) cases for thyroid neoplasms as shown in figure 1.

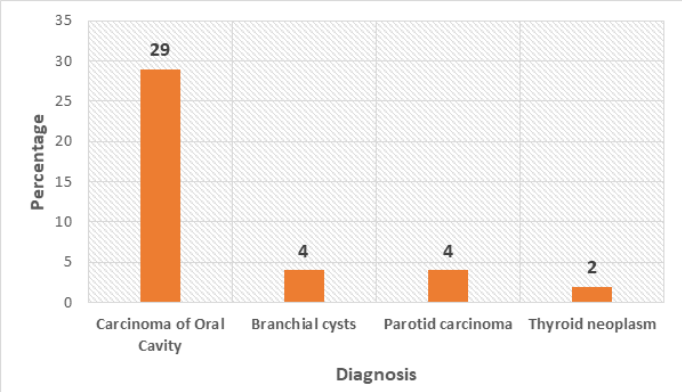

Figure 2: Pathological diagnosis of neck surgeries in the study

Among 39 patients, unilateral neck dissection/surgery were done for 31 (79.48%) and bilateral neck dissection/surgery were done for 8 (20.51%) of cases. Therefore, considering neck surgeries done in each side as one case, total 47 cases were recorded regarding anatomical relationship findings.

Most commonly the SAN was found positioned lateral to the IJV at the superior margin of the posterior belly of digastric muscle in 35 (74.46%) of cases and designated as Group A. The SAN was positioned medial to the IJV at this level in 9 cases (19.14%) and designated as Group B, and the SAN travelled directly through the IJV in 3 case (6.38%) and designated as Group C. (Table 2)

It was found that there was one variability between the sides in a subject who underwent a bilateral neck dissection, in which on one side the SAN was lateral to the IJV and on the other side the SAN was medial to the IJV.

Table 2: Intraoperative anatomical findings of relationship between SAN and IJV at PBD.

Category	Frequency	Percentage
Group A	35	74.46
Group B	9	19.14
Group C	3	6.38
Total	47	100

Discussion

The eleventh cranial nerve is the SAN. The SCM and trapezius muscle are innervated by a motor nerve (somatic nerve). The nerve is at risk of injury during level II neck dissection, and/or neck surgeries in the region. The risk increases even more due to presence of anatomical variations of the nerve course in respect to IJV. The information about possible variations of SAN course in the region of neck helps surgeons to minimize the nerve injury and thus morbidity.

Suarez[8] introduced FND with the preservation of the IJV and/or the SAN in 1963, following which various modifications to RND have been proposed and demonstrated in several studies.[10] In order to facilitate the safe identification of the SAN, numerous studies have described the anatomical landmarks and their variations; nevertheless the majority of these descriptions specifically concentrate on the landmarks located at the posterior triangle of the neck.[15] There are relatively few literature that focuses on the nerve's course in the upper neck in relation to its surrounding structures.[6] After the establishment of ND procedures, in the management of head and neck cancers, it has become important to know the anatomical relationship between the SAN and the IJV in the upper part of the neck because during almost every ND procedure, it is always mandatory to remove level II lymph nodes for oncological clearance.[23] In order to prevent the shoulder disability, it is justifiable to preserve the SAN during ND and lymph node biopsy, if feasible.3 Shoulder pain, restricted movement and drooping of shoulder are the hallmarks of shoulder syndrome, which can be caused by iatrogenic injury to the SAN during ND and result in serious and unavoidable morbidity.[6,9,11,23] With the increasing use of SND, iatrogenic injury to the SAN can be avoided, with a detailed knowledge of the anatomy and the course of the SAN in the upper neck.[6] In our study, there were total of 39 patients who underwent neck surgeries for various head and neck pathologies. In doing so, we discovered a preponderance of the lateral orientation of the SAN relative to the IJV.

Hinsley et. al did an observational cross-sectional study on

"Anatomic relationship between the Spinal Accessory Nerve and Internal Jugular Vein in the upper neck" and found that out of 116 ND, in 112(96%) SAN were positioned lateral to IJV at the level of PBD muscle and 3(3%) was positioned medial and 1(1%) travelled directly through the IJV.[11] According to the study "Intraoperative relationship of the spinal accessory nerve to the internal jugular vein: Variation from cadaver studies" done by Christine B. Taylor, out of 207 ND, in 198(95.7%) SAN were lateral/superficial to IJV at the level of upper border of PBD muscle, 6(2.8) passed medial/deep, 2(0.9%) traversed through the vein and 1(0.48%) divided travelling both lateral and medial to the IJV.[19]

A case study done by Dhawan et. al on 'A Rare anatomical relationship of Spinal Accessory Nerve to Internal jugular vein' noted to have a unique relationship of SAN and IJV in a patient with squamous cell carcinoma (SCC) of right retromolar region of the mandible and undergoing staging ND. At the upper ND (level II), the SAN was observed to pass directly through the IJV. A variable relation makes it prone to injury during level II dissection with resultant morbidity.[23] In a prospective study by D. Levy et. al "Relations of the accessory nerve with the internal jugular vein: surgical implications in cervical lymph node clearances", it included 91 patients operated for conservative cervical lymph node clearance. During the 91 surgical procedures (123 nodal clearances), in 122 cases the nerve passed infront and lateral to the IJV and in only one case the nerve passed medial and the behind the IJV. So, the study concluded when the nerve is lateral to the IJV it is usually protected but, when it is medial and posterior to the IJV, it may be damaged by the surgeon.[24]

In a case report by N C. Ozturk et. al "Fenestration of Internal jugular vein and relation to Spinal accessory nerve: Case report and review of literature", it reported a unilateral fenestration of the IJV on right side, and the SAN passed through the fenestrated vein, pierced the carotid sheath, and then reached the SCM. Venous fenestration is an uncommon neck condition. Such variations should be kept in mind during various surgical dissections and radiological interventions in the neck.[25]

In the study, the patient's age ranged from 17 to 70 years and the mean age was 49.59 years with SD of 12.57 years. The most common age group that underwent surgery was 46 to 60 years. These findings are comparable to the study by Yigit et. al where age range of patients was 18 to 50 years, and the mean age was 38.5 years.[26] But the findings were different from the studies done by Hone et. al, Lee et. al and Taylor et. al where mean age were 65.5 years, 31.7 years and 63.4 years respectively, which were relatively higher.6,7,19 Among 39 patients who underwent neck surgeries, 32 (82.05%) were male and 7 (17.94%) were female. In a study conducted by Yigit et. Al, among 39 patients, 29 (74.35%) were male and 10 (25.64) were female.26 But, a study conducted by Saman et. al also had female predominance with 55.73% female and 44.26% male among 61 patients.[27]

In our study, the total number of neck dissections/surgeries done for 39 patients were 47, among which 31(79.48%) were unilateral and 8(20.51%) were bilateral. Our study showed similarity with the study done by Dailiana et. al in which unilateral ND was performed in 17(85%) and bilateral ND was performed in 3(15%) of total 20 patients that underwent ND.28 Similarly, in a study done by Hinsley et. al and Soo et. al which included 86 patients and 23 patients, 56(65.11%) and 14(60.86%) had unilateral ND and 30(34.48%) and 9(39.13%) had bilateral ND respectively.[11,29]

Our study included forty-seven neck surgeries done for different head and neck pathologies. These included 29(74.35%) cases done for oncological diagnosis and treatment, 4(10.25%) cases for branchial cyst where ND was not done but just relationship of the SAN and IJV was studied, 4(10.25%) cases for parotid carcinoma and 2(5.12%) cases for thyroid neoplasm. There was a similar study done by Nilakantan et. al in 2006, in which ND was done for primaries from different sites including oral cavity 12(44.44%), oropharynx 2(7.4%), hypopharynx 4(14.8%), larynx 6(22.22%) and unknown primary 3(11.11%) respectively.[30] Another study done by Taylor et. al had 127 ND done for different cases including oncological treatment 153(70.50%), branchial cyst 10(4.6%), carotid body tumors 5(2.3%), vagal paragangliomas 2(0.9%) and high carotid artery exposure 2(0.9%).[19]

In our study, we tried to locate the position of the SAN higher up in the neck at the level of posterior belly of the digastric muscle. In doing so we found the predominant lateral location of the SAN relative to the IJV. The SAN was located lateral to the IJV at the superior margin of posterior belly of the digastric muscle in 35(74.46%) of ND, medial to the IJV at this level in 9(19.14%) and the SAN traveled through the IJV in 3(6.38%) of the cases in a total of 47 neck surgeries.

In a similar study done by Hinsley et. al, the SAN travelled lateral to the IJV in 112(96%) of ND, medial to the IJV in 3(3%) and travelled directly through the IJV in 1(1%) of the total 116 live ND.[11] Likewise, Taylor et. al performed 207 live ND in which, the SAN was positioned lateral to the IJV in 198(95.7%), medial to the IJV in 6(2.8%), and directly through the IJV in 2(0.9%) of the cases.[19] In another study done by Levy et. al in 2001 in which he performed 123 live ND for nodal clearance, there was overwhelming preponderance of the SAN lateral to the IJV in 122(99.2%) of the cases.[24]

There are also several cadaveric NDs done to find out the position of the SAN. In a study done by Krause et. Al,[31] in which he dissected 94 cadaveric necks and found out that the SAN was located lateral to the IJV in 72.5% and medial to the IJV in 26.4% of the cases. Saman et. al conducted 84 cadaveric ND and found that the SAN was located lateral to the IJV in 80%, 19% medial, and passed through the IJV in 1% cases respectively.[27] There are other several cadaveric ND, which pointed out the medial predominance of the SAN in relation to the IJV. In a study conducted by Kierner et. al, the SAN passed ventrally to the IJV in 24(56%) and dorsally to the IJV in 19(44%) of cases of total 43 ND.[15] Another study in 32 cadavers by Soo et. al, where the SAN travelled lateral to the IJV in 18(56%) and medial to the IJV in 14(44%).[29] Similarly, Lee et. al and Amuti et. al conducted a study in 181 and 80 ND, where the SAN was located medial to the IJV in 104(57.4%) and 68(85%), and lateral to the IJV in 72(39.8%) and 12(15%) of the cases respectively.[6,17]

Few previous studies have reported on the incidence of the SAN passing through the fenestrated IJV. Hollinshead reported

identifying 3.2% during cadaver dissection, Prades et. al reported 4(0.4%) cases of this anomaly per 1000 ND and Lee et. al encountered this anomaly in 5(2.8%) cases during 181 ND. Hashimoto et al reported this clinical incidence was 4 (2.1%) per 192 unilateral ND.10 In our study, the incidence of the SAN passing through the IJV was 1(3.22%) per 31 ND.

To summarize, there are similarities as well as discrepancies between our study to other studies. We have mentioned that the lateral orientation of the SAN is far more common than the medial orientation. These variations may be due to several factors. Levy et. al reported the intraoperative collapse of the IJV leading to the false identification of the SAN medial to the IJV.24 This finding might explain the higher incidence of the medial course of the SAN relative to the IJV in cadaveric studies. Also, as our study documented the SAN higher up in the neck, at the level of superior border of PBD muscle, this may account for the differences with other intraoperative ND studies that may have identified the nerve lower in the neck before it had crossed over the vein. It should also be noted that the SAN exits the skull base in the JF medial to the IJV. So during cadaveric NDs, the nerve is often traced to the skull base. For these reasons, the nerve might have been reported to be medial to the IJV in cadaveric NDs. Surgeons should be careful during routine neck explorations, as the SAN is likely to be encountered lateral to the IJV at the level of the posterior belly of digastric muscle.19 Thus, to prevent injury to the SAN and the IJV, the surgeons should be clear about the relation between the nerve and the vein and the level at which the nerve is being identified.

Conclusion

The posterior belly of the digastric muscle is the most common location at which the SAN is encountered. The majority of the SANs course lateral to the IJV at the level of the posterior belly of the digastric muscle. Thus, knowledge of this anatomical relationship and possible rare variations may help surgeons minimize the potential risk of injuring both of these structures during neck dissections.

Recommendations

Location of the SAN should always be sought out in relation to the IJV.

This will help surgeons to prevent iatrogenic injury to both of these structures and avoid morbidity associated with its injury.

Limitations of the Study

The sample size was small.

This study gives idea about common location of the SAN in relation to the IJV but, multicenter larger studies should be carried out.

Acknowledgements

I would like to thank all the patients who participated in the study.

Conflict of Interests

The authors have declared that no conflict of interests.

Financial Disclosure

The authors received no specific funding for this work.

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