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Anatomic Relationship between the Spinal Accessory Nerve and the Internal Jugular Vein in the Upper Neck during Neck Dissection: A Prospective Study

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Abstract

Objectives: To find the intraoperative relationship between the spinal accessory nerve (SAN) and the internal jugular vein (IJV) in the upper neck, at the level of the superior border of the posterior belly of the digastric muscle.

Methods: A prospective study was carried out in the Department of Otorhinolaryngology and Head and Neck Surgery, B. P. Koirala Institute of Health Sciences, Dharan from December 2019 to November 2020.

Results: Thirty-nine patients were enrolled in the study who met the inclusion criteria. The mean age of the patient was 49.59 years with an SD of ±12.571 years. The age of the patients ranged from 17 to 70 years. The most common age group was 46 to 60 years (46.16%). The maximum number of patients were male which accounted for 32 (82.05%) and 7 (17.94%) were female. Unilateral neck dissections were done for 31 (79.48%) and bilateral neck dissections were done for 8 (20.51%) cases. The most common diagnosis for which neck dissections were carried out was carcinoma of the oral cavity (29 cases, 74.35%) followed by branchial cysts (4 cases, 10.25%), parotid neoplasms (4 cases, 10.25%) and thyroid neoplasms (2 cases, 5.12%).The SAN was positioned lateral to the IJV at the superior margin of the posterior belly of the digastric muscle in 35 (74.46%) of neck dissections, medial to the IJV at this level in nine cases (19.14%) and the SAN traveled directly through the IJV in three cases (6.38%).

Conclusion: The posterior belly of the digastric muscle is the most common location at which the SAN is encountered..

Introduction

The spinal accessory nerve (SAN) is the eleventh cranial nerve. The accessory nerve has two roots- a cranial part and a spinal part. The cranial part arises from the nucleus ambiguous and also from the dorsal nucleus of the vagus nerve. The cranial part leaves the medulla oblongata as four or five rootlets which unite together and then join the spinal part of the accessory nerve just as it enters the jugular foramen (JF). It is only united with the spinal part for a short course before uniting with the inferior ganglion of the vagus nerve. So, these cranial fibers will then pass to the recurrent laryngeal and pharyngeal branches of the vagus nerve, ultimately destined for the muscles of the soft palate (except tensor veli palatini). [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 posterior to the vertebral arteries. Then it passes to the JF where it receives some fibers from the cranial root. The SAN exits the JF with the ninth and tenth cranial nerves as well as the internal jugular vein (IJV) [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 deep surface of the sternocleidomastoid (SCM) muscle. Branches are sent to the SCM muscle that it innervates. [5]

Ever since neck dissection (ND) was first described by George Crile in 1906, [6-8] it has played an important role in the management of metastatic nodal disease in head and neck cancer. [6] Radical neck dissections (RND) involve the sacrifice of the SAN and result in restricted shoulder abduction and postoperative pain. [9] This shoulder morbidity has been a major impact on the movement away from RND and towards functional neck dissections (FND). 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, an SND often aims to further reduce risk to the SAN by avoiding a level V dissection altogether. [11, 12] When shoulder dysfunction occurs in the absence of a level V dissection, the likely culprit is an injury at the level II region. [13] In a level II neck dissection, the SAN is commonly identified initially at the anterior border of the SCM. It is then skeletonized anterosuperiorly [14] and followed deep to the PBD muscle, and it is here that injury most likely can occur. 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. [11,15,16]

Thus, this variability between the SAN and the IJV is widely accepted in the published literature and anatomy textbooks. [15,16] Hence, the goal of the study was to intra operatively observe the course of the SAN in relation to the IJV at the superior border of the PBD muscle to determine its frequency at each of the three possible positions.[11] These relations and positions are, however, not

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observed in the Nepalese population. 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. Therefore, the primary objective of the study is to find the intraoperative relationship between the SAN and the IJV in the upper neck, at the level of superior border of PBD muscle. The secondary objectives were to observe the frequency of SAN passing lateral to IJV, the frequency of SAN passing medial to IJV, and to observe the frequency of SAN passing directly through IJV.

Materials and Methods

Study Population

This is a prospective study enrolling patients from the Department of Otorhinolaryngology-Head and Neck Surgery fulfilling the inclusion criteria. The study duration was from December 2019 to November 2020.

The study population involved all the patients who underwent unilateral or bilateral level II neck dissection for the treatment or diagnosis of head and neck pathology and procedure where the relationship between SAN and IJV could be assessed.

All the cases fulfilling the inclusion criteria were included in this study. Non-probability convenient sampling was done and all the consecutive samples were included.

The inclusion criteria included those patients undergoing unilateral or bilateral level II neck dissection for head and neck pathology and procedure where the relationship between SAN and IJV could be assessed and those who consented to surgery. Neck dissection not involving level II, patients undergoing revision surgery, and intraoperative location of the SAN at the level of the digastrics muscle which could not be ascertained were excluded.

Sample Size Estimation

This Study Considers 95% Ci And 80% Power To Estimate Sample Size. According To The Literature Review Taylor Et. Al [19, 20],It Was Found That Spinal Accessory Nerve Passed Through Internal Jugular Vein In Only 2% Of Cases Which Is The Minimum Prevalence.

According To Previous Records Of The Medical Record Section, It Was Found That Only 24 Cases Had Undergone Neck Dissections For Head And Neck Pathologies In The Department Of Otolaryngology. Therefore, The Final Sample Size Estimation Formula Was Used To Estimate The Sample Size As Follows. (Cdc Atlanta Who Usa Epi Info 2007). The Sample Size Is 24, And A Total Of 24 Cases Were Enrolled For This Study.

Ethical Clearance

Ethical Clearance was obtained from the Institutional Review Committee, B.P. Koirala Institute of Health Sciences.

Study Method

A prospective study was done where all the patients diagnosed with Head and Neck pathology after history, general and systemic examination, Ear Nose Throat (ENT), and Head and Neck examination and confirmed via cytopathology and/or histopathology report and undergoing unilateral or bilateral neck dissection were included in this study.

A cross-sectional method was done and the patient was allocated to one of the following groups:SAN lateral(superficial/ventral) to IJV (Group A), SAN medial(deep/dorsal) to IJV (Group B), and SAN passing directly through IJV (Group C).

A subject enrollment form was filled and the eligible patient was offered detailed printed information about the proposed study. Patients agreeing to take part in the study were requested to sign the consent form. After signing the consent, the patient was recruited for the study.

Enrollment of Patients

Patients without any discrimination of sex, race, religion, and geography that fulfill the inclusion criteria mentioned above were eligible for the clinical study. A prior informed written and understood consent was taken from each patient after explaining in detail the procedures, possible complications, and outcomes.

A detailed clinical history, thorough general, physical, ENT, and Head and Neck examinations were carried out and the findings were recorded in the predesigned Proforma. Pre-operative investigations along with a CT scan of the neck from the base of the skull to the upper mediastinum were performed.

Steps of operation

Selective Neck Dissection

Anesthesia, positioning, and draping: The operation was done under general anesthesia. The patient was placed in a supine position with the neck extended and the head turned to the opposite side.

Operative steps

The neck was opened via a horizontal incision placed in a skin crease just below the level of the hyoid bone. The incision was made through the skin, subcutaneous fat, and platysma muscle and identified the external jugular vein and greater auricular nerve overlying the SCM. Next, the superior skin flap was elevated with cautery in a subplatysmal plane until the submandibular salivary gland is identified. Electrocautery or a scalpel was used to raise an inferiorly based subplatysmal flap, exposing anteriorly up to the omohyoid and inferiorly, the lateral surface of the SCM almost to the clavicle. Lymph nodes were resected from the submental triangle (Level Ia) with electro-cautery up to the hyoid bone.

Next Level Ib of the neck was addressed. The fascia (capsule) overlying the submandibular gland was incised midway over the gland and was dissected from the gland in a superior direction in a subcapsular plane to avoid injury to the marginal mandibular nerve. The marginal mandibular nerve crossed the facial artery and vein. The facial artery and vein are identified by blunt dissection with a fine hemostat. Next attention was directed to the fat and lymph nodes tucked anteriorly between the anterior belly of the digastric and mylohyoid muscle.

Facial vessels for facial lymph nodes were palpated; if present, they were dissected free using fine hemostats, the care is taken not to

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traumatize the marginal mandibular nerve. The facial artery and vein were then ligated and divided close to the submandibular gland so as not to injure the marginal mandibular nerve. This frees up the gland superiorly, which can then be reflected away from the mandible. The mylohyoid muscle was retracted anteriorly with a right-angled retractor. The clearly defined interfascial dissection plane between the deep aspect of the submandibular gland and the fascia covering the XIIn is opened with finger dissection. The XIIn was visible in the floor of the submandibular triangle. Inferior traction on the gland brings the lingual nerve and the submandibular duct into view. The submandibular duct was separated from the lingual nerve, ligated, and divided. The submandibular ganglion, suspended from the lingual nerve, was clamped, divided, and ligated.The facial artery was divided and ligatedjust above the posterior belly of digastric. The external jugular vein was retracted laterally with the SCM muscle which allowed access to Levels IIa and IIb. The greater auricular nerve was preserved.The fascia was divided along the lateral aspect of the posterior belly of the digastric. The posterior belly of digastric was exposed along its entire length where facial vein crossed.

The XIIn was identified below the greater cornu of the hyoid bone anterior to where it crossed the external carotid artery. Carefully dissected along the nerve in a posterior direction and divided all the veins crossing the nerve to expose the full length of XIIn.

After the nerve had crossed posterior to the external carotid artery, the SCM branch of the occipital artery was identified that tethered the XIIn. Dividing this artery releases the XIIn. The nerve then coursed vertically along the anterior surface of the IJV and hence leads the surgeon directly to the IJV. Using dissecting scissors or a hemostat to part the fatty tissue behind the IJV in Level II, the surgeon next identified the XIn which may course lateral (commonly), medial (uncommonly), or through (very rarely) the IJV. The upper part of the SCM was retracted posteriorly to expose Level IIb. With a hemostat, create a tunnel immediately posterior to the IJV down to the prevertebral muscles.

The transverse process of the C1 vertebra was palpated immediately posterior to the XIn and IJV and served as an additional landmark for the position of these structures in difficult surgical cases. In order to resect Level IIb, identify the XIn in Level IIb, and atraumatically dissect it free from the surrounding fat with sharp and blunt dissection up to where it enters the SCM

The occipital artery passed across to the top of Level IIb; its branches were cauterized should they be severed while dissecting the superior part of Level IIb.

To resect Levels II and III, extend the incision along the posterior edge of the deep aspect of SCM inferiorly through the fatty tissue of Level III in anterograde direction. The anterograde dissection was continued with a scalpel or scissors until the ansa cervicalis, and the carotid sheath containing the common and internal carotid arteries, Xn and IJV were sequentially exposed. The carotid sheath was incised along the full course of the vagus nerve, and the neck dissection specimen was stripped off the IJV while dissecting inside the carotid sheath. The fat and lymphatics around the anterior aspect of IJV was continued stripping until the common carotid artery was again reached. The tributaries of the IJV were divided and ligated with silk ties.

The final stepwas to complete stripping the neck dissection specimen off the infrahyoid strap muscles taking care not to injure the XIIn and its accompanying veins superiorly, and to deliver the neck dissection specimen. The neck was irrigated with warm water, the anesthetist was asked to do a Valsalva maneuver so as to elicit unsecured bleeding vessels and chyle leakage, and a 5mm suction drain was inserted. The neck was closed in layers with continuous vicryl to platysma and sutures/staples to the skin.

Postoperative care

The drain was maintained on continuous suction e.g. low-pressure wall suction, until the drainage volume was <30ml /24hrs.

Statistical Analysis

Data were collected as per the proforma. Data editing and entry were done on the same day to ensure consistency and quality of data. 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 study was carried out in the Department of Otorhinolaryngology and Head and Neck surgery from December 1, 2019 to November 30, 2020, where fourty seven ND of 39 patients were performed.

Demoghraphic distribution

Total of 39 patients that met the inclusion criteria were included in this study.

Age Distribution

The mean age of patient was 49.59 years with SD of ±12.571 years. The age of the patients ranged from 17 to 70 years. 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).

Gender Distribution

Among 39 patients, 32 (82.05%) were male and 7 (17.94%) were female.

Neck Dissections

Total number of neck dissections carried out for different head and neck pathologies among 39 patients were 47. Among thirty-nine patients, unilateral neck dissections were done for 31 (79.48%) and bilateral neck dissections were done for 8 (20.51%) of cases.

Diagnosis of different pathologies

Among thirty-nine neck dissections carried out for different head and neck pathologies, majority of cases consisted of Neck Dissection done for oncological diagnosis and treatment i.e. 29 cases (74.35%). And, remainder of cases were neck dissection done for various other surgeries 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 (Figure1).

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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	

Table 2: Intraoperative findings

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

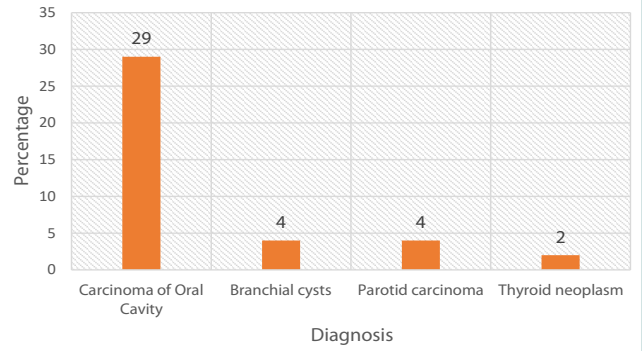

Figure 1: Diagnosis of different pathologies

Intraoperative 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 neck dissections and designated as Group A. The SAN was positioned medial to the IJV at this level in nine cases (19.14%) and designated as Group B, and the SAN travelled directly through the IJV in three case (6.38%) and designated as Group C.

It was found that there was only one variability between the sides in the subjects 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.

Discussion

The SAN is the eleventh cranial nerve. It has a motor nerve (somatic nerve) innervating two muscles – the SCM and trapezius. It has two components – a spinal part and a cranial part. The cranial part of accessory nerve is from the vagus nerve, but not all individuals have a cranial root.[21] The spinal part arises from the first five or six cervical spinal nerves. The spinal portion then ascends through the foramen magnum passing laterally to join with the cranial root. As the two nerves join, they then pass through the JF, along with the glossopharyngeal and vagus nerves. The cranial part then passes to the superior ganglion of the vagus nerve and distributed primarily in the branches of the vagus. The spinal portion then goes on to supply the SCM and trapezius in the neck. [1]

Richard W. Nason et. al performed an observational study "The Anatomy of the Accessory Nerve and Cervical Lymph Node Biopsy". There should be detail knowledge of the courses of the nerve and its anatomic relations in avoiding injury. Useful anatomical landmarks were the proximal IJV in the anterior triangle and Erb's point in the posterior triangle. The transverse process of the atlas can be easily palpated in the upper anterior triangle between the tip of the mastoid and ramus of the mandible. The proximal IJV lies immediately anterior to this point and is the key to identifying the proximal course of the accessory nerve. The SAN runs from the foramen jugulare to the border of trapezius. It is vulnerable to injury in surgical procedures involving either the anterior the posterior cervical triangles. Injury to the accessory nerve is reported to be the most frequent complication of surgical procedures in the posterior triangle of the neck. [5, 22]

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, 112(96%) were found lateral to IJV at the level of PBD muscle and 3(3%) was positioned medial and 1(1%) travelled directly through the IJV. A lateral position high in the neck creates increased exposure of nerve in this area and can endanger it during level II ND. Therefore, a complete understanding of Anatomy of SAN in upper neck will potentially reduce the potential risk of iatrogenic injury of the SAN and 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 found out that out of 207 ND, 198(95.7%) 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. The anatomic course of the SAN remains area of debate in cadaveric studies where the nerve passed medial to IJV more frequently than laterally. The study concluded that this might be due to intraoperative collapse of the IJV in cadaveric studies leading to false identification of nerve medial to the IJV. Other possibility could be that the nerves are often traced to the skull bases during cadaver dissections, and the SAN exits the skull base in the JF medial to the IJV. Thus this study has mentioned the location of SAN at the level of PBD muscle. It is important to note that a minimal number of patients will have aberrant anatomy and understanding such variation will allow for safe preservation of the nerve.[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. At the upper ND (level II), the SAN was observed to pass directly through the IJV. A patient with squamous cell carcinoma (SCC) of right retromolar region of the mandible and undergoing staging ND was noted to have this unique relationship. Although most of the studies report a higher incidence of lateral relation of SAN to IJV compared with medial relation, there is a lot of variation in the incidence of lateral and medial relation in different studies with a rare data of SAN emerging directly through the IJV. A variable relation makes it prone to injury during level II dissection with resultant morbidity. Therefore, one must be aware and have knowledge of these anatomical variations to minimize this risk of injury to the SAN and IJV. [23]

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D. Levy et. al conducted a prospective study "Relations of the accessory nerve with the internal jugular vein: surgical implications in cervical lymph node clearances". The study included 91 patients operated for conservative cervical lymph node clearance between December 1993 to October 1999. During the 91 surgical procedures (123 nodal clearances), in 122 cases the nerve passed in front and lateral to the IJV and in only one case the nerve passed medial and the behind the IJV. So, 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]

N C. Ozturk et. al published a case report "Fenestration of Internal jugular vein and relation to Spinal accessory nerve: Case report and review of literature". The study 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 a rarely seen entity in the neck. Fenestrations and complete divisions of the vasculature have been described in many of the craniocervical arteries, but venous fenestrations are rarely described. There was confusion between the terms: duplication and fenestration in literature which are typically used interchangeably. Such variations should be kept in mind during various surgical dissections and radiological interventions in the neck. [25]

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] There are many studies that describe the anatomical landmarks and their variations to aid safe identification of the SAN, but majority of these descriptions specially focus on the landmarks in the posterior triangle of the neck.[15] There are relatively few literature that focuses on the course of the nerve with relation to its surrounding structures in the upper neck.[6] A complete understanding of the SAN anatomy in the superior neck at the level of posterior belly of digastric muscle, especially how it relates to the IJV, has been previously absent in the Nepalese population.

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] Preservation of the SAN during ND and lymph node biopsy is justifiable whenever possible to prevent shoulder disability. [3] Iatrogenic injury to the SAN during ND may result in significant and unavoidable morbidity if the form of shoulder syndrome which is characterized by shoulder pain, restricted movement and drooping of shoulder.[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 ND for various head and neck pathologies. In doing so, we discovered a preponderance of the lateral orientation of the SAN relative to the IJV.

Age

The age of the patients ranged from 17 to 70 years. The mean age of the patient was 49.59 years with an SD of 12.571 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]

Gender

Among 39 patients who underwent neck dissections, 32 (82.05%) were male and 7 (17.94%) were female. Among 39 patients, 29 (74.35%) were male and 10 (25.64) were female in a study conducted by Yigit et. al.[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]

Neck Dissections

In our study, the total number of neck dissections 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] But in the contrary, in a study done by Yigit et. al, 31(79.48%) had bilateral ND and 8(20.51%) had unilateral ND of total 39 patients.[26]

Diagnosis of different pathologies

Our study included forty-seven ND 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]

Intraoperative Findings

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 ND.

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

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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%, 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 due to the partial collapse of the IJV. Also, as our study documented the SAN higher up in the neck, at the level of superior border of posterior belly of the digastric 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 jugular foramen 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 vast majority of the SANs coursed lateral to the IJV at the level of the posterior belly of the digastric muscle. Thus, from this information and thorough knowledge of the SAN anatomy and its intimate and variable relationship with the IJV, surgeons will be able to minimize the potential risk of injuring both of these structures during neck dissections. Given the morbidities associated with iatrogenic injury to the SAN, surgeons should also be aware of the rare relationship between these structures.

Ethical Clearance

Ethical Clearance was obtained from the Institutional Review Committee, B.P. Koirala Institute of Health Sciences.

Availability of Data and Materials: All relevant data are within the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

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Authors Contribution

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