



### REVIEW ARTICLE

## SPINAL ACCESSORY NERVE: ANATOMICAL VARIATIONS AND ITS SIGNIFICANCE DURING NECK DISSECTION IN HEAD AND NECK CANCER

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### Manuscript Info

#### Manuscript History

Received: 25 January 2020

Final Accepted: 27 February 2020

Published: March 2020

### Abstract

Spinal accessory nerve plexus includes the spinal accessory nerve with all its Intra- and extracranial connections to other nerves. Neck dissection is an important technique for the treatment of cervical lymph node metastasis in patients with head and neck cancer. Due to the adverse effects of radical neck dissection, a progressively more conservative functional neck dissection including preservation of the spinal accessory nerve is no longer an exception. Iatrogenic injury to the spinal accessory nerve can have medico-legal implications. Despite the presence of many described techniques to locate the nerve, it still remains vulnerable to damage during neck dissection due to its variations in the course and relations with other structures. Since the introduction of functional neck dissection, various modifications have been made to reduce the adverse effects of radical neck dissection. This paper describes the variations of the spinal accessory nerve in the neck and surgical significance which will guide head and neck oncosurgeons in imbibing adequate knowledge and using efficient techniques during surgical neck dissections.

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### Introduction:-

Curative management of the neck is the most important prognostic factor for head and neck cancer. Neck dissection is a surgical procedure performed to excise cervical lymph nodes in such patients for staging and treatment purpose<sup>1</sup>

Crile<sup>2</sup> in 1906 was the first to describe radical neck dissection (RND). Byers RM<sup>3</sup> in 1985 conducted a study on 967 patients and strongly suggested that surgical removal of spinal accessory nerve is unnecessary and leaving it insitu would have no adverse affect on the prognosis. Hence, many modifications have evolved which have reduced the morbidity rate. Various types of neck dissection have been described by Robbins<sup>4</sup>. Suarez<sup>5</sup> in 1963 introduced functional neck dissection (FND) with preservation of the spinal accessory nerve and/or internal jugular vein (IJV) as the sequel of RND lead to severe morbidity and postoperative complications, such as dropped shoulder and pain.

Spinal Accessory Nerve (SAN) is arguably one of the most important structures encountered during these procedures which requires skill and experience during its dissection and once isolated, provides clear landmarks intra-operatively, allowing accurate and precise surgery. Injury or resection of the SAN results in considerable morbidity and post operative complications more commonly to the shoulder region<sup>1</sup>.

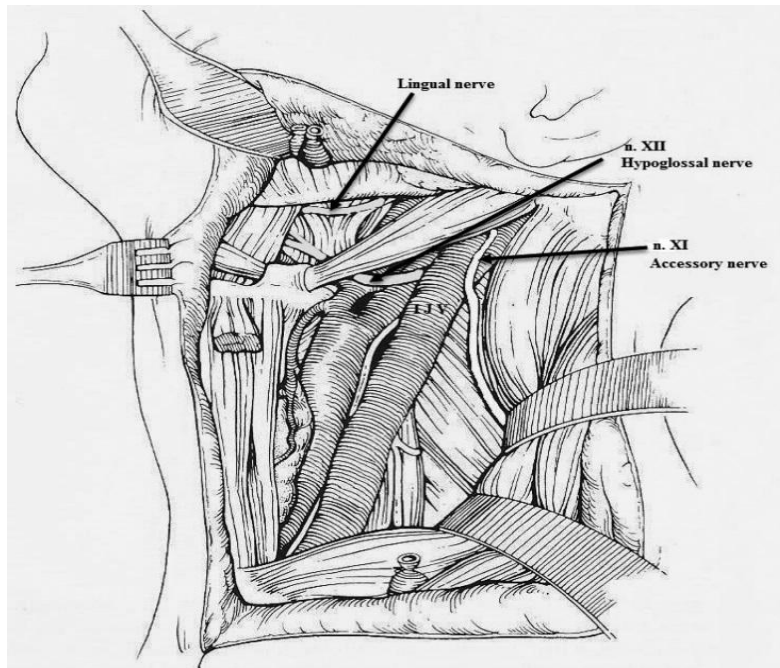
SAN arises from the first five cervical spinal segments and receives numerous communications from the second and third cervical nerves upon crossing the posterior triangle of the neck over the levator scapulae<sup>6</sup>

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The two muscles innervated by the spinal accessory nerve are sternocleidomastoid and trapezius. Both muscles have different origins. The sternocleidomastoid muscle is branchiomic, i.e., of the branchial arch origin, whereas the trapezius muscle is telomeric, i.e., of the somatic origin. Sternocleidomastoid muscle functions in turning the head in 3 dimensional movements. The innervation of the sternocleidomastoid muscle is mostly stated by the teleological theory which describes the cranial innervation of the muscle, almost always by the SAN. On the other hand, trapezius muscle does not serve the function like sternocleidomastoid muscle, hence, postulating an occasional innervation by the SAN or more commonly by a combination of cranial and cervical nerves, or rarely by the cervical nerves alone<sup>7,8</sup>.

#### Anatomical variations and relations:

The term anatomical variation differs from the concept of anomalies, abnormalities and malformations and is defined as the normal range in topography and morphology of the body structures. With the new advances in imaging techniques and surgical procedures, emergence of a new field of research for descriptive anatomy is necessitated<sup>9</sup>.



**Figure 1:-** Course of Spinal Accessory Nerve and its relations.

#### Spinal Accessory Nerve-Internal Jugular Vein Relation:

Gardiner<sup>1</sup> in 2002 described a case study of a 67-year-old male diagnosed with squamous cell carcinoma of the left lateral border of the tongue with left SAN seen coursing through the centre of the IJV while dissecting at the upper end of the IJV (level II).

M Iseri<sup>10</sup> in 2007 also described a rare anomaly of SAN coursing through the centre of IJV on the left side of neck during dissection with normal anatomical relation of SAN on the right side of the neck.

Y Hashimoto<sup>11</sup> in 2012 encountered a rare anomaly of the SAN passing through the fenestrated IJV in four cases during neck dissection.

WH Hollinshead<sup>12</sup> in 1985 encountered similar anomalies during cadaveric dissection accounting to 3.2%,

Prades et al<sup>13</sup> in 2002 reported 4 (0.4%) cases per 1,000 unilateral neck dissections and Lee et al<sup>14</sup> in 2009 encountered this anomaly in 5 (2.8%) cases during 181 neck dissections.

Towbin and Kanak<sup>15</sup> in 2004 reported two cases of the IJV fenestration as observed by means of CT angiography.

Williams et al.<sup>16</sup> in 1989, Caliot et al.<sup>17</sup> in 1989, and Ayeni et al.<sup>18</sup> in 1995 described two arrangements of the descending branch of the SAN and the IJV. The anterior variant (More common), where SAN crosses in front of the vein and follows a spiral course on its lateral surface and finally entering the sternocleidomastoid muscle (75–90%). The posterior variant was less common where the nerve crosses behind the vein (10–25%).

ML Hinsley<sup>19</sup> in 2010 conducted a study on 116 neck dissections in which SAN was found to be oriented lateral to the IJV at the level of the superior border of the posterior belly of the digastric muscle in 112 (96%) necks, medial to the IJV in three necks (3%), and transverse directly through the IJV in one (1%)

Embryologically, three hypotheses have been described to explain the duplication of IJV. These include Vascular, Neural and Bony hypotheses. The vascular hypotheses<sup>13</sup> is most accepted according to literature which states that in the foetal life SAN passes between two veins: the medial and the lateral vein. The lateral vein lies superficial to SAN and it usually disappears. The medial vein rarely disappears leaving the nerve lying deep to the vein. The appearance of a secondary venous ring surrounding the SAN at the lower level is thought to result in duplication which persists during adult life<sup>20</sup>.

According to the neural hypotheses, SAN emerges in the neck at the level of the transverse process of the atlas vertebrae lying 2cm below the process hinders the development of IJV leading to duplication. The bony hypothesis suggests that the cause of venous duplication is due to variations in the ossification of the bony bridges. However, it does not explain the relation of IJV to SAN<sup>21</sup>.

#### **Spinal Accessory Nerve-Trapezius Muscle Relation:**

The relationship of the SAN with the trapezius muscle has also found to be disproportionate in certain cases. Stacey<sup>22</sup> in 1996 reported a case with absence of normal anatomical branching of SAN to the trapezius muscle on one side of the neck which implied motor innervation by cervical nerves only.

Consequently various animal studies conducted by Ueyama et al.<sup>23</sup> in the Japanese monkey (*Macaca fuscata*), Reighard and Jennings<sup>24</sup> in the cat by and later by Rose et al.<sup>25</sup>, all indicate that only motoneurons of the spinal accessory nerve innervate the trapezius muscle. On the contrary, Gurushanthiah<sup>25</sup> observed innervation of both cervical and SAN in the Bonnet monkey (*Macaca radiata*).

Kierner et al.<sup>27</sup> in 2002 identified a small cranial branch innervating the used descending part of the trapezius muscle using electromyography which was present in the posterior triangle of the neck medial to the trapezius muscle. However, no relevant clinical contribution to the motor innervation of the trapezius muscle was demonstrated.

#### **Spinal Accessory Nerve-Sternocleidomastoid Muscle Relation:**

Piersol's experience at the University of Pennsylvania<sup>28</sup> showed that the nerve exited at approximately the mid-point in five cases, between the junction of the upper and middle third in four cases and absence of SAN in three subjects during dissection.

Shiozaki et al.<sup>29</sup> performed a detailed cadaveric anatomical study and described three types of SAN-sternocleidomastoid innervations: type A being non-penetrating type; type B being partially penetrating type; type C being completely penetrating type.

#### **Significance During Neck Dissection:**

A proper technique is crucial for the head and neck surgeons to identify and isolate SAN. After raising of the subplatysmal flaps, the anterior border of the sternocleidomastoid muscle is delineated. A sharp dissection is done to divide the fascia that binds sternomastoid muscle to the infrahyoid strap muscles. The posterior belly of digastric muscle is retracted to open the loose areolar tissue on the inner aspect of sternomastoid that separated it from IJV. A plexus of veins is encountered which drains the sternomastoid into pharyngeal plexus of veins. SAN lies 2mm deep to these veins which is exposed after ligation of these veins and careful sharp dissection of the fascia below the veins. The nerve is isolated cranially till the skull base and caudally till the anterior border of the trapezius muscle.<sup>30</sup> (Figure 1)

SAN is related variably close to IJV in the upper part of posterior triangle of neck. Precise knowledge of anatomical variations between the SAN and IJV in this region of neck is required during level II lymph node dissection. The

morbidity from the loss of SAN function is substantial, with post-operative complications including shoulder weakness, shoulder drop, loss of shoulder elevation and chronic shoulder pain. Hence, complete knowledge of the anatomical arrangement, topography, morphology of SAN and dissection under vision is extremely important to prevent inadvertent injury to the nerve. It is also important to alert head and neck surgeons performing neck dissections to another possible relationship between the nerve and adjacent structures and nerve anomalies in order to prevent accidental injuries.<sup>19</sup>

Surgical excision of cervical plexus nerves during neck dissection should be avoided, each of which may have important sensory as well as motor functions. Furthermore, the prognosis remains the same and surgical excision is often unnecessary. Other structures that are no longer commonly removed are sternocleidomastoid muscle, the internal jugular vein, and certain group of lymph nodes. Hence, optimum neck dissection also avoids unscrupulous iatrogenic injury to the spinal accessory nerve plexus<sup>31</sup>

### Conclusion:-

As head and neck cancer surgeries require a multidisciplinary teamwork, thorough knowledge of the anatomical variations of the SAN, morbidity could be significantly reduced and the surgical outcome of head and neck operations would surely be improved. Despite centuries of intensive study by learned and capable scholars, many aspects of the anatomy of this structure still remain unknown. More knowledge in this area will assist us in better planning surgical head and neck dissections to improve outcomes; and, even more importantly, to improve our patients' well being and quality of life.

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