Original article

# Accessory nerve: topographic study of its spinal root in human foetuses

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## Abstract

**Objective:** The spinal accessory nerve (SAN) within the posterior triangle (PT) is the commonly injured nerve in the body. Recognizable landmarks to locate this nerve in PT may help the surgeon in identifying it for repair, use of it in peripheral nerve neurotisation, or avoiding it as in proximal brachial plexus repair. The present study was undertaken to offer reliable superficial landmarks for the identification of the SAN within the PT. **Material and methods:** The neck was dissected in 16 foetal cadavers (total 32 PT). The foetuses were divided into 2 groups depending upon their age- group 1 (13-24 weeks) and group 2 (24-38 weeks). Morphometric studies in terms of distances and angles were conducted in both groups on the SAN and its anatomical surrounding landmarks. **Results**: The mean of all the parameters which we have measured in both groups of foetuses to locate the SAN is given in the tables in results. Mean angle which the SAN makes after exiting from SCM in group 1 and group 2 on right and left side is 73.3° and 60.5°,65° and 57.1° . Mean angle which the SAN makes before its entry into trapezius in group 1 and group 2 on right and left side is 41.4° and 62.2°, 41.4°and 66.4°. **Conclusion:** The exact localization of the spinal root of the accessory nerve within the posterior triangle of the neck will help surgeons to avoid its injury while performing surgery at this site.

**Keywords:** spinal accessory nerve, posterior triangle, external acoustic meatus, clavicle, surgical anatomy.

## 1 Introduction

The accessory nerve is the 11th cranial nerve and is formed from two roots, a cranial root and a spinal root. The cranial root originates from the vagal nuclei and finally joins with the vagus nerve and supplies some of the muscles of the soft palate and larynx. The spinal root originates from the spinal accessory nucleus inside the upper five cervical segments of the spinal cord. It provides motor innervation to the sternocleidomastoid (SCM) and trapezius muscles (Figure 1). Injury to this portion of the nerve is more common, and clinically significant, than injury to the cranial portion (LLOYD, 2007).

This nerve is often encountered in neck surgery, and is at risk of iatrogenic damage, resulting in the 'shoulder syndrome'. This results from weakness of the trapezius muscle, with subsequent drooping of the shoulder and prominence of the scapula. This results in strain on the remaining functional shoulder muscles, namely the levator scapulae and the rhomboids, and eventual pain. In addition, there is failure to abduct the arm beyond 90° (LLOYD, 2007).

The morphological and topographic anatomy of the SAN is vital for surgical interventions in the anterior or PT of the neck. The preservation of the SAN prevents anatomical deformities and movement dysfunctions that occur when the SAN is sacrificed during neck dissections (DURAZZO, FURLAN, TEIXEIRA et al., 2009).

Inoue, Nibu, Saito et al. (2006) have presented that preservation of the SAN also has an important effect on the quality of life after neck dissections (INOUE, NIBU, SAITO et al., 2006). Preservation of the SAN during neck dissections is considered a standard of care in the surgery concerning the PT. Morris, Ziff and Delacure (2008) stated that maximum iatrogenic damages of the SAN happened from cervical lymph node biopsies carried out regularly by general surgeons and otolaryngologists (MORRIS, ZIFF and DELACURE, 2008).

Accurate and rapid identification of the SAN is dependent on consistent surgical landmarks. Although an array of literature was found on morphometry and relationship of SAN in adults, literature was deficient in children, infants and foetuses which are important for paediatric surgeons working on this field as in the case of neck dissection essential for operative procedures. So, this morphometric study was undertaken to note relationship of SAN with different cervical structures adjacent to the nerve that can be used to localize this cranial nerve during neck dissections.

## 2 Material and methods

In this study 32 PT from 16 formalin fixed human foetuses in the Department of Anatomy KMC, Manipal were dissected. The foetuses were divided into 2 groups according to their age- group 1 (13-24 weeks) and group 2 (24-38 weeks). Out of 16 foetuses there were 9 foetuses in group 1 (7 females and 2 males) and 7 in group 2 (3 females and 4 males). Dissection of the PT was done according to the guidelines of Cunningham's Manual of Practical Anatomy. Measurements were made in both groups between the SAN and surrounding landmarks using a digital calliper and a protractor (goniometer) on both sides of the neck (Figure 2). Measurement which were done are:

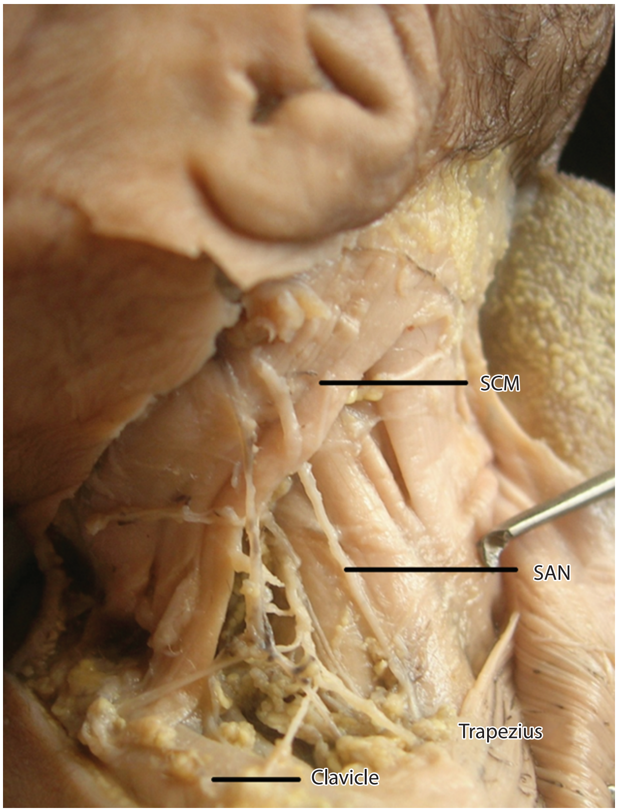


**Figure 1.** Showing the course of SAN (Spinal accessory nerve) in PT (posterior triangle).

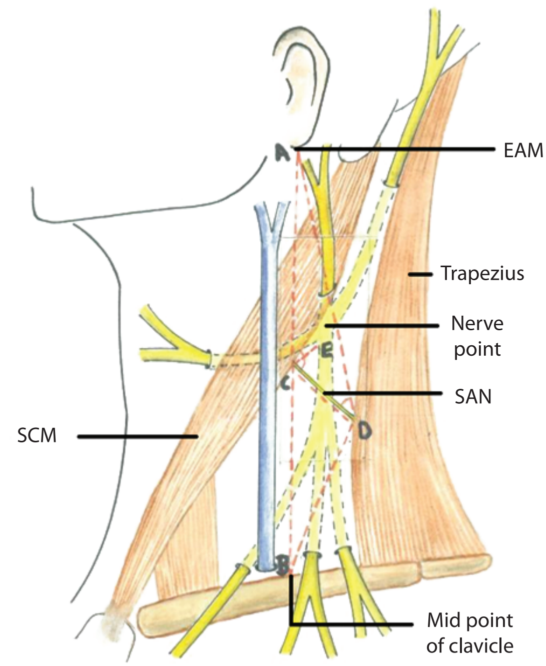


**Figure 2.** Showing the measurements done for SAN (Spinal accessory nerve). BC- Distance between the exit point of the SAN from the posterior border of the SCM (Sternocleidomastoid muscle) and midpoint of the clavicle, AC- Distance between the exit point of the SAN from the posterior border of the SCM and EAM (External acoustic meatus), AD- Distance between the entry site of the SAN into the trapezius and EAM, BD- Distance between the entry site of the SAN into the trapezius and midpoint of the clavicle, CE- Distance between the exit point of the SAN from the posterior border of the SCM and nerve point, CD - Whole length of SAN in PT (posterior triangle).

- The distance between the entry site of the SAN into the trapezius and midpoint of the clavicle;
- The distance between the entry site of the SAN into the trapezius and the lower edge of external acoustic meatus (EAM);
- The distance between the exit point of the SAN from the posterior border of the SCM and midpoint of the clavicle;
- The distance between the exit point of the SAN from the posterior border of the SCM and the lower edge of EAM;
- The distance between the exit point of the SAN from the posterior border of the SCM and nerve point. The nerve point is defined as the spot in the posterior border of the sternocleidomastoid muscle in which a bundle of sensory nerves coming from the cervical plexus exits;
- The angle, which is formed by the SAN after exiting from the SCM;
- The angle, which is formed by the SAN before entering into the trapezius; and
- The whole length of SAN in PT.

Digital photographic documentation was done. Statistical analysis for all the measurement was done and tabulated.

## 3 Results

Out of 16 foetuses there were 9 foetuses in group 1 (7 females and 2 males) and 7 in group 2 (3 females and 4 males).

The mean of all the parameters which we have measured in both groups of foetuses to locate the SAN is given in the tables. (Table 1 and 2)

Mean angle which the SAN makes after exiting from SCM on right and left side is 73.3° and 60.5°. While the range varies from 60-80° and 40-80° on right and left side respectively.

Mean angle which the SAN makes before its entry into trapezius on right and left side is 41.4° and 62.2°. While the range varies from 20-75° and 50-80° on right and left side respectively.

Mean angle which the SAN makes after exiting from SCM on right and left side is 65° and 57.1°. While the range varies from 40-80° and 50-70° on right and left side respectively.

Mean angle which the SAN makes before its entry into trapezius on right and left side is 41.4° and 66.4°. While the range varies from 30-50° and 50-80° on right and left side respectively.

## 4 Discussion

The main complication of neck dissection and surgery at the PT of the neck is the shoulder syndrome, which results from SAN damage. So, to avoid this we have identified various landmarks to localise the nerve in the PT before doing the surgery in the neck.

### 4.1 Distance between the entry site of the SAN into the trapezius and midpoint of the clavicle

In the present study, it was found that the mean distance from the point at which SAN enters the trapezius muscle to clavicular midpoint was 1.7 cm and 1.6 cm on right and left side in 13-24 weeks foetuses. While it was 1.7 cm and 2.3 cm in foetuses of 25-38 weeks. age group. Previous authors in adults have found the mean distance of the point SAN enter trapezius muscle to clavicular midpoint was 4.5 cm, 5.2 cm, 6 cm, 4.8 cm respectively (ARAMRATTANA, SITTITRAI and HARNSIRIWATTANAGIT, 2005; DAILIANA, MEHDIAN and GILBERT, 2001; SALGARELLI, LANDINI, BELLINI et al., 2009; TUBBS, SALTER, WELLONS et al., 2005). Hone and colleagues work on operative cases suggests that the SAN passes under the trapezius at a mean distance of 51 mm above the clavicle (HONE, RIDHA, ROWLEY et al., 2001). Eisele et al. propose that the point at which the nerve passes under the trapezius is 3–5 cm above the clavicle (EISELE, WEYMULLER JUNIOR and PRICE, 1991). Chen et al., A Symes and H Ellis found the distance between the SAN entering the trapezius muscle and the clavicle was 4.96 ± 0.78 cm, 4.08 ± 1.47 SD (CHEN, WANG, LIANG et al., 2006; SYMES and ELLIS, 2005). Soo and colleague's work on cadavers suggests that an entry point in the trapezius 2-4 cm above the clavicle is by far the most common, although this distance may be as much as 7 cm (SOO, GUILOFF, OH et al., 1990).

### 4.2 Distance between the entry site of the SAN into the trapezius and EAM

In the present study we found the mean distance of the point SAN enter trapezius muscle to EAM on right and left side in foetuses of 13-24 weeks is 2.8 cm and 2.9 cm, in 25-38 weeks foetuses it was 4.0 cm and 3.7 cm respectively.

### 4.3 Distance between the exit point of the SAN from the posterior border of the SCM and midpoint of the clavicle

In our study we found the mean distance between the exit point of the SAN from the posterior border of the SCM and midpoint of the clavicle on right and left side in foetuses of 13-24 weeks is 2.1 cm and 2.1 cm, in 25-38 weeks foetuses it was 2.8 cm and 2.8 cm respectively. While Kierner et al. and Lu et al. have done the study in adults and they found that the distance range was 7-9 cm and 5.7 to 12.9 cm respectively (KIERNER, ZELENKA, HELLER et al., 2000; LU, HAMAN and EBRAHEIM, 2002).

### 4.4 Distance between the exit point of the SAN from the posterior border of the SCM and EAM

In the present study we found the mean distance between the exit point of the SAN from the posterior border of the SCM and EAM on right and left side in foetuses of

**Table 1.** Mean of the parameters for group 1.

| Parameters in foetuses of 13-24 weeks | Mean | | Range | |
|---|---|---|---|---|
| | Right (cm) | Left (cm) | Right (cm) | Left (cm) |
| Distance between the entry site of the SAN into the trapezius and midpoint of the clavicle. | 1.7 | 1.6 | 1.1-3.0 | 1.2-2.1 |
| Distance between the entry site of the SAN into the trapezius and EAM. | 2.8 | 2.9 | 2.0-3.7 | 2.1-3.5 |
| Distance between the exit point of the SAN from the posterior border of the SCM and midpoint of the clavicle. | 2.1 | 2.1 | 1.2-3.5 | 1.4-3.0 |
| Distance between the exit point of the SAN from the posterior border of the SCM and EAM. | 1.8 | 1.7 | 1.3-2.5 | 1.4-2.4 |
| Distance between the exit point of the SAN from the posterior border of the SCM and nerve point. | 0.3 | 0.3 | 0.2-0.5 | 0.2-0.4 |
| Whole length of SAN in posterior triangle. | 1.3 | 1.6 | 0.8-1.8 | 0.9-2.1 |

**Table 2.** Mean of the parameters for group 2.

| Parameters in foetuses of 25-38 weeks | Mean | | Range | |
|---|---|---|---|---|
| | Right (cm) | Left (cm) | Right (cm) | Left (cm) |
| Distance between the entry site of the SAN into the trapezius and midpoint of the clavicle. | 1.7 | 2.3 | 1.2-2.0 | 1.6-2.9 |
| Distance between the entry site of the SAN into the trapezius and EAM. | 4.0 | 3.7 | 3.1-5.5 | 2.3-5.2 |
| Distance between the exit point of the SAN from the posterior border of the SCM and midpoint of the clavicle. | 2.8 | 2.8 | 2.5-3.2 | 2.2-3.5 |
| Distance between the exit point of the SAN from the posterior border of the SCM and EAM. | 2.1 | 1.8 | 1.9-2.5 | 1.3-2.7 |
| Distance between the exit point of the SAN from the posterior border of the SCM and nerve point. | 0.4 | 0.5 | 0.3-0.6 | 0.3-0.7 |
| Whole length of SAN in posterior triangle. | 2.2 | 2.2 | 1.4-3.1 | 1.5-3.0 |

13-24 weeks is 1.8 cm and 1.7 cm in 25-38 weeks foetuses it was 2.1 cm and 1.8 cm respectively.

### *4.5 Distance between the exit point of the SAN from the posterior border of the SCM and nerve point*

In our study we found the mean distance between the exit point of the SAN from the posterior border of the SCM and nerve point on right and left side in foetuses of 13-24 weeks is 0.3 cm and 0.3 cm in 25-38 weeks foetuses it was 0.4 cm and 0.5 cm respectively. While Marcelo D. Durazzo et al. have done the study in adults and they found the mean distance was 0.97 ± 0.46 cm (DURAZZO, FURLAN, TEIXEIRA et al., 2009).

### *4.6 Whole length of SAN in posterior triangle*

In the present study we found the whole length of SAN in the posterior triangle on right and left side in foetuses of 13-24 weeks is 1.3 cm and 1.6 cm in 25-38 weeks foetuses it was 2.2 cm and 2.2 cm respectively. While Marcelo D. Durazzo et al. has done the study in adults and they found the mean length of SAN in posterior triangle was 5.27 ± 1.52 cm (DURAZZO, FURLAN, TEIXEIRA et al., 2009). Dailiana et al., Hone and colleagues, Eisele et al., Soo and colleagues found the length of SAN was ranging from 2.5-4 cm in their studies (DAILIANA, MEHDIAN and GILBERT, 2001; HONE, RIDHA, ROWLEY et al., 2005; EISELE, WEYMULLER JUNIOR and PRICE, 1991; SOO, GUILOFF, OH et al., 1990). Tubbs RS et al. found the mean length of SAN was 3.5 cm (TUBBS, SALTER, WELLONS et al., 2005).

### *4.7 Mean angle which the SAN makes after exiting from SCM*

In our study we found the mean angle which the SAN makes after exiting from SCM on right and left side in foetuses of 13-24 weeks is 73.3° and 60.5° in 25-38 weeks foetuses it was 65° and 57.1° respectively.

### *4.8 Mean angle which the SAN makes before its entry into trapezius*

In our study we found the mean angle which the SAN makes before its entry into trapezius on right and left side in foetuses of 13-24 weeks is 41.4° and 62.2° in 25-38 weeks foetuses it was 41.4° and 66.4° respectively. While Marcelo D. Durazzo et al. have done the study in adults and they found the mean angle between the nerve and the anterior border of the trapezius muscle was 15 ± 8° (DURAZZO, FURLAN, TEIXEIRA et al., 2009).

After comparing the parameters of the present study with the adult parameters, we established that the foetal parameters are entirely different from the adults. These differences are due to the size and age of the foetuses, because in our study we have seen that as the age of the foetuses are increasing the dimensions are also increasing accordingly.

In our study we have measured one new parameter i.e. the distance of entry and exit of SAN from trapezius and SCM to EAM which the previous studies have not done.

Iatrogenic damage to the SAN has been usually documented and can have medico-legal allegations. The subsequent syndrome of pain, paralysis and winging of the scapula are frequently the basis of significant morbidity. Making a map to describe the surface anatomy of the SAN in the PT is an impracticable goal given its extensive variations in man. Prevention of injury to the SAN cannot be attained by slavishly following to surface markings given in textbooks, but only by careful dissection during operations on the PT. Iatrogenic injury, however, accounts for the bulk of cases of SAN palsy seen. This may be deliberate, as the unavoidable consequence of a classical radical neck dissection for the removal of cervical node metastases from head and neck squamous carcinomas. More frequently the nerve is injured accidentally as a consequence of minor surgical procedures in the neck, frequently after lymph node biopsy, or benign tumour removal in the PT. The number of iatrogenic lesions of the SAN resulting such procedures is hard to determine, although several studies quote biopsy or excision of cervical lymph nodes in the PT as the most common cause (SYMES and ELLIS, 2005).

Prevention of this damage in children should always be possible. A detailed understanding of the complex topographical anatomy of the PT is paramount (GROSSMAN, RUCHELSMAN and SCHWARZKOPF, 2008).

Greater awareness by anatomists and surgeons concerning anatomic variation of the SAN would have an influence on the quality of life of patients who undergo surgical intervention in the neck (DURAZZO, FURLAN, TEIXEIRA et al., 2009).

These all parameters will help in identification of SAN while doing procedures in PT on children. In children the nerve can be damaged iatrogenically while doing lymph node biopsy or removing a benign cyst like branchial cyst or cystic hygroma in PT.

We believe that our study will provide support to the foetal anatomy, concerning surgical procedures and biopsy which are done in children in PT like removal of cystic hygroma and lymph node biopsy. This is the first reported study on morphometry of the foetal SAN. This study is important not only for paediatric surgeons, but also for anatomists and embryologists.

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