# Surgical anatomy of structures adjacent to the thyroid apex and post-operative voice change (A review including dissection)

*by*

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**Summary**

This paper considers the anatomy of structures contiguous to the upper pole of the thyroid gland. It also describes the findings of an anatomical dissection confined to the muscular and carotid triangles of the neck with the nerves therein innervating the cricothyroid and infrahyoid muscles. The segmental nature of the latter is described. The variable course of the cricothyroid artery with regard to the sternothyroid muscle is noted. A superficially placed artery is accompanied by branches of the ansa cervicalis; a deeply placed one is related to the external laryngeal nerve.

In addition to the external laryngeal nerve there are other nerves, including branches of the ansa cervicalis, which can be damaged during operations involving the thyroid apex or adjacent structures. A comment is made about the significance of these findings with particular reference to voice change.

## Introduction

It is common surgical practice to tie the superior thyroid pedicle as close to the apex of the gland as possible to avoid damage to the external laryngeal nerve. The superior pole vessels are tied in a bunch (Grey Turner, 1948) or by individual ligation (Sow *et al.*, 1982), as advocated in the more recent literature.

Knowledge of the surgical anatomy of this area is relatively limited (Sow *et al.*, 1982). This study was undertaken to examine nerves and arteries located in the vicinity of the thyroid apex, with special attention given to the superficially placed cricothyroid artery, the external laryngeal nerve and the ansa cervicalis.

There are four nerves which are vulnerable during thyroidectomy. The recurrent laryngeal, the external laryngeal, branches of the ansa cervicalis and the sympathetic trunk. The recurrent laryngeal a branch of the vagus, innervates most of the intrinsic muscles of the larynx and can be damaged when the inferior thyroid artery is ligated in continuity or divided. The external laryngeal, a branch of the superior laryngeal, is the nerve supply to the cricothyroid muscle and is vulnerable at the time of division of the superior thyroid vessels. The ansa cervicalis, formed in part by the descendens hypoglossi, supplies the infrahyoid muscles and may be injured when transecting these muscles. The cervical sympathetic trunk; source of sympathetic supply to the upper limb, head and neck, is liable to injury when the inferior thyroid artery is being sought (Kyle and Hardy, 1981).

Damage to some of these nerves at the time of operation can interfere with the functional integrity of the larynx (Sabiston, 1986; Durham and Harrison, 1964; Gray, 1980; Harries, 1955; Menasche *et al.*, 1976; Reeve *et al.*, 1969). Knowledge of variations which can occur in the course and relations of these nerves would be of benefit to both surgeon



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and patient. The surgical anatomy of the recurrent laryngeal nerve and its common variations have been well described and will therefore not be considered here (Sabiston, 1986; Aird, 1957). Far less information is available about variations that can occur in the course of the external laryngeal nerve (Sow *et al.*, 1982).

With regard to the innervation of the infrahyoid muscles, their segmental nature (Grant, 1956, 1980; Last, 1978; Quain, 1839) and possible variations (Gray, 1980; Grant, 1956; Last, 1978) thereof are overlooked in surgical textbooks; and the relationship of these segmental nerves to arteries is not commented upon in any of the literature referred to.

The external laryngeal, because of its very close proximity to the superior thyroid artery, is the nerve most likely to be injured when the upper pole vessels are divided (Sow *et al.*, 1982; Menasche *et al.*, 1976; Grant, 1980). However, there are other nerves which can be near the apex of the thyroid gland. The sympathetic trunk is deep to the carotid sheath but may be placed in the operative field when the carotids are retracted (Aird, 1957). Sympathetic nerves accompany the superior thyroid artery and its cricothyroid branch (Cunningham, 1981). Rarely the recurrent laryngeal nerve may be placed close to the thyroid apex (Sabiston, 1986) when the gland is small. Sometimes the superior laryngeal is in the vicinity of a thyroid apex which has been pushed up by an unusually large gland (Durham and Harrison, 1964); or, because of traction on the pretracheal fascia at operation, the nerve may be pulled into the operative field (Durham and Harrison, 1964). The descendens hypoglossi is another nerve which is closely related (Quain, 1923; Cunningham, 1967) to the thyroid apex. In markedly enlarged glands the apex has been seen next to the hypoglossal nerve (Author). Thus, it is not only the external laryngeal nerve which may be damaged when the upper pole is being mobilized. Other nerves can also be involved, their location depending on variations in the topographic anatomy.

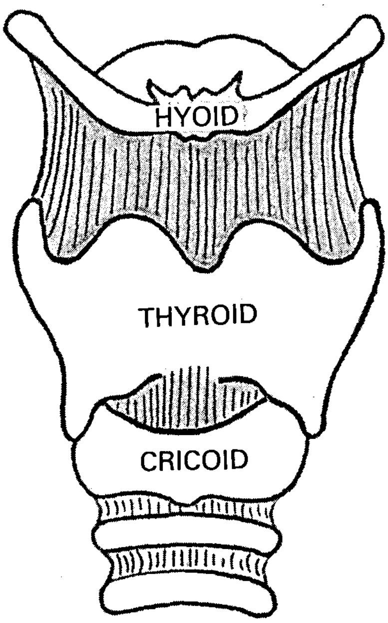

Fig. 1
Larynx.

For example, the infrahyoid muscles can show differences in form. The site and shape of the thyroid gland has variations, and the position of the apex changes with the degree of glandular enlargement (Grey Turner, 1948). The superior thyroid artery has a variable origin and distribution. These and other differences will be considered in greater detail in the text so as to give a better understanding of the surgical anatomy of nerves which are placed in the area.

## Anatomy

*Larynx*

In the embryo, the larynx is placed opposite the atlas (Wilson, 1962). At birth it is level with the disc of the fifth cervical vertebra and with growth further descent occurs down to a level corresponding to the body of the sixth cervical vertebra.

Individual variations in the anatomy of the larynx do occur (Paparella and Shumrick, 1980) but the basic structure remains the same and consists of three parts (Fig. 1), a foundation formed by the cricoid cartilage, above which is the thyroid cartilage and further up the hyoid bone. These three are interconnected by various ligaments and membranes, giving a flexible unit. Superiorly it is in continuity with the laryngopharynx and inferiorly the trachea.

The oblique line of the thyroid cartilage (Fig. 2) is the site where a number of muscles and deep fascia are attached—the thyrohyoid, sternothyroid, inferior constrictor and the pretracheal fascia. The term 'oblique' can be misleading, as only the inferior extremity of the line can be thus described; the superior half is placed in an almost vertical plane, offering little barrier to cephalad extension of the thyroid apex.

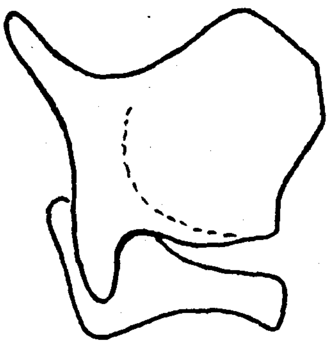

FIG. 2
Oblique line of thyroid cartilage.

*Thyroid gland*

The thyroid gland has two lateral lobes connected across the midline by an isthmus which overlies the second to fourth tracheal rings. The parathyroids are posterior to the thyroid lobes. The trachea and oesophagus are medial relations of the lateral lobes which occupy an area extending from the oblique line of the thyroid cartilage, to a level corresponding to the first thoracic vertebra or the upper limit of the sternal end of the clavicle (Hamilton *et al.*, 1971; Robinson, 1973). The level is not static and it can show differences depending on the actions of the externally placed laryngeal muscles, the neck position and inspiratory movements (Paparella and Shumrick, 1980). The clavicular reference point may itself be variable.

Many (Cunningham, 1981; Gray and Skandalakis, 1972) anatomic variations of the thyroid gland, most of them rare, have been described. The thyroid develops from a groove behind the tuberculum impar. The thyroglossal duct extends from the foramen caecum of the tongue to the isthmus of the thyroid gland (Das, 1968) and it is along the course of this duct that the thyroid descends during its development; in protochordates (Haines and Mohiuddin, 1972) this duct apparently represents the opening into the pharynx of an ordinary exocrine gland. The tract (or its remnants) is usually placed anterior to the hyoid bone but it may be posterior or may pass through its substance (Last, 1978; Wilson, 1962; Gray and Skandalakis, 1972).

The thyroid may be arrested in its descent at different levels (Gray and Skandalakis, 1972; Nixon and O'Donnell, 1966) or, as a result of the pull of the heart (Harrison, 1963), may show hyperdescent (Gray and Skandalakis, 1972) along the defect in the pretracheal fascia. The right lobe is usually the larger of the two (Paparella and Shumrick, 1980) and rarely a lobe may be absent (Gray and Skandalakis, 1972). The isthmus may contribute the bulk of the gland (Sutton, 1980), and it may be placed high, low or be absent. The pyramidal lobe, sometimes connected to the levator glandulae thyroideae, is usually situated to the left of the midline, but it can be in the centre, to the right, below the isthmus or double (Cunningham, 1981; Gray and Shandalakis, 1972). The gland is relatively larger in women and children than in men (Cunningham, 1967).

In addition to anatomic considerations, familial (Hutchinson, 1967), dietary (Samson Wright, 1982) and hormonal (Gannong, 1969) factors influence its size. The hormone levels may be associated with circadian rhythms (Conroy and Mills, 1970). Substantial enlargement (Aird, 1957; Hutchinson, 1967; Davidson, 1967; Micks, 1951; Mitchie, 1978) or decrease (Mitchie, 1978) in size does occur with medication, and pathologic processes affect form (Anderson, 1964).

*Pretracheal fascia*

The thyroid has a true or visceral capsule. Outside this it is invested with pretracheal fascia; this is the surgical capsule of the thyroid which is a component part of the deep fascia of the neck. The pretracheal fascia extends from the hyoid bone above to the fibrous pericardium below (Ellis, 1983). It is attached posterolaterally to the carotid sheath (Grant, 1980) and anteriorly it is in contact with the infrahyoid muscles. It is also fixed to the oblique line of the thyroid cartilage, to the cricoid cartilage by 'suspensory' ligaments (Paparella and Shumrick, 1980) and to the upper part of the trachea (Nouveau Larousse, 1952). Defects in the pretracheal fascia determine the direction in which the thyroid expands or descends (Ellis, 1983). Descent usually occurs in front of the trachea or rarely posteriorly, between the oesophagus and the vertebral column (Sweet, 1949). On the left side posterior extension is unlikely because the oesophagus is placed slightly to the left of the midline near the superior thoracic aperture and acts as a barrier.

*Carotid sheath*

The carotid sheath is a term given to a condensation of the deep fascia found on both sides of the neck. It extends from the base of the skull to the superior thoracic aperture.

It transmits the common carotid artery, the internal carotid artery, internal jugular vein and the vagus nerve. The sheath is loosely connected by areolar tissue anterolaterally and posteriorly—to the deep lamina of the investing layer of deep fascia and prevertebral fascia respectively. Inferiorly and anteromedially it is firmly attached to the pretracheal fascia. At this level various other nerves are related to the carotid sheath, including the descendens hypoglossi, the sympathetic trunk and the cardiac branches of the vagus. The early course of the phrenic nerve is separated from it by the prevertebral fascia.

*Muscles*

The muscular and carotid triangles occupy an area in the neck below the hyoid bone and inferior to the posterior belly of the digastric muscle, the sternocleidomastoid muscles form the posterolateral boundaries. A large number of muscles are found in this region of the neck including the muscles of the larynx, which are divisible into intrinsic and extrinsic groups.

With the exception of the cricothyroid muscle the intrinsic muscles are contained within the larynx and act directly on the vocal cords or glottis and are supplied by the recurrent laryngeal nerve.

The cricothyroid muscle, which tenses the vocal cords, is usually designated as an intrinsic muscle (Scott-Brown, 1979) of the larynx placed externally and innervated by the external laryngeal. It is termed an extrinsic muscle by some authors (Grant, 1980; Paperella and Shumrick, 1980). An apt name is the tuning-fork of the larynx (Du Plessis, 1975).

The extrinsic group, which pass between the larynx and neighbouring structures, include the suprahyoid and infrahyoid or strap muscles (Gray, 1980). These muscles elevate and depress the larynx, and they may also lengthen or shorten the vocal cords in certain head positions (Paparella and Shumrick, 1980). The digastric, stylohyoid, mylohyoid and geniohyoid are the suprahyoid muscles; they elevate the larynx. The stylopharyngeus, palatopharyngeus and inferior constrictor, which have also been included in the extrinsic group of muscles in one surgical textbook (Scott-Brown, 1979), are also elevators of the larynx.

The infrahyoid muscles (Fig. 3) consist of the sternohyoid, sternothyroid, omohyoid and thyrohyoid muscles, attached to the larynx externally and innervated from cervical cord segments one to three through the ansa cervicalis. Variations in these muscles can occur (Quain, 1923). The thyrohyoid muscle may be split longitudinally, its medial fibres may insert into the thyroid capsule and act as a levator of the thyroid gland. The sternothyroid muscle can be partially or wholly continued into the thyrohyoid without interruption or may be fused with the sternohyoid, bundles may be given off to the fascia over the carotid vessels, it may also be split long-

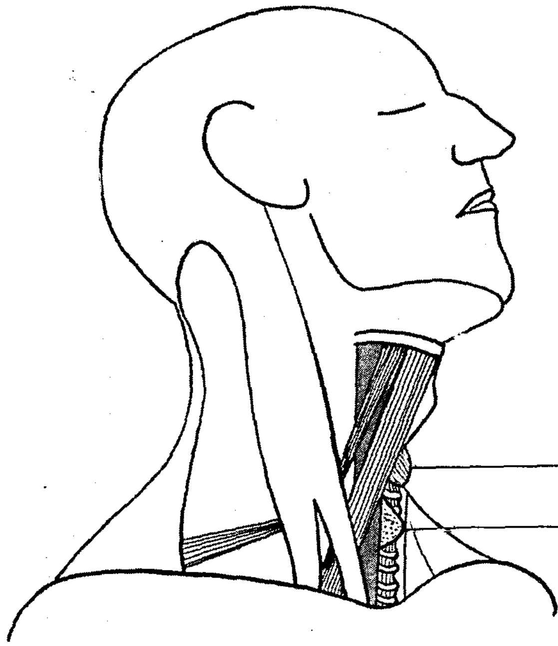


FIG. 3
Cricothyroid and infrahyoid muscles.

itudinally. The sternohyoid may be fused with the omohyoid or be longitudinally split. The sternothyroid and sternohyoid, in addition, can occasionally have tendinous intersections, and the omohyoid itself can have variations. It is of interest to note that in some mammals there is apparently a continuous muscle sheath representing these muscles (Henry, 1970). With regard to their actions, the infrahyoid group are depressors of the larynx and become effective during deglutition, mastication and speech (Gray, 1980; Paparella and Shumrick, 1980).

*Nerves*

The external laryngeal nerve is a branch of the superior laryngeal, derived from the inferior vagal ganglion. The superior laryngeal nerve descends deep to the carotids and comes to overlie the middle constrictor muscle (Spalteholz, 1903), thereafter dividing to form the internal and external laryngeal nerves. After a short course, the internal laryngeal pierces the thyrohyoid membrane and supplies the mucosa of the upper half of the larynx, most of the lower half being supplied by the recurrent laryngeal. The external laryngeal in its course is usually placed deep (Durham and Harrison, 1964; Bruce *et al.*, 1964; Johnston, 1968) to the superior thyroid artery and then follows the deeply placed cricothyroid artery to innervate the cricopharyngeus and cricothyroid muscles. It also supplies the fibrous capsule of the cricothyroid joint and the mucosa lining the infraglottic larynx at the level of the cricothyroid membrane (Paparella and Shumrick, 1980; Scott-Brown, 1979). It receives a communicating branch from the superior cervical ganglion of the sympathetic and sends communicating cardiac and pharyngeal branches (Buchanan, 1949). Its terminal course is accepted as being deep to the insertion of the sternothyroid muscle; however, a branch superficial to this muscle has also been illustrated in one textbook (Grant, 1956).

The external laryngeal nerve can have a

variable origin (Spalteholz, 1903; Visset *et al.*, 1975) and course (Menasche *et al.*, 1976). It may be placed deep or superficial to the superior thyroid artery (Durham and Harrison, 1964), and it has a variable position with regard to the veins (Visset *et al.*, 1975). It may have a spiral course (Menasche *et al.*, 1976) around the vascular pedicle and there may be from two to eight branches near the thyroid apex (Durham and Harrison, 1964). The relationship of the nerve to the upper pole is also variable (Menasche *et al.*, 1976). The site at which it pierces the cricothyroid muscle differs (Sow *et al.*, 1982; Menasche *et al.*, 1976). A branch penetrates the cricothyroid membrane to enter the larynx (Durham and Harrison, 1964) and another branch is given off to supply the thyroid gland (Quain, 1839; Visset *et al.*, 1975). It has connections to a plexus of nerves situated in its vicinity to which the recurrent laryngeal and superior laryngeal contribute (Visset *et al.*, 1975). Side differences have also been noted (Durham and Harrison, 1964). Finally, if placed deep to the inferior constrictor muscle, it may remain undetected (Kark *et al.*, 1984).

In addition to the external laryngeal nerve there are sympathetic filaments accompanying the superior thyroid artery (Cunningham, 1981). These nerves arise from the superior cervical ganglion of the sympathetic trunk which is placed deep to the carotid sheath. The sympathetic trunk is an extension of the thoracic sympathetic system into the neck. There are three ganglia along the nerve in the neck: upper, middle and lower. These are placed at the levels of the hyoid bone, the cricoid cartilage and the neck of the first rib respectively. Branches from these ganglia are distributed to the head, neck, upper limb and cardiac area by arteries, somatic nerves and plexuses. The sympathetic nerves, coming from the superior and middle ganglia, are vasomotor to the thyroid and possibly effect secretion of thyroid hormone (Paparella and Shumrick, 1980).

Outside the base of the skull the hypoglossal nerve in its descent communicates with the vagus and the sympathetic trunk. It receives C1 fibres from the cord and, on reaching the carotid triangle, makes a curve with its convexity inferior, crosses the lingual artery and proceeds towards the inferolateral aspect of the tongue, to which it is motor. From the convexity arise three branches— descendens hypoglossi, the nerve to the thyrohyoid and the nerve to the geniohyoid. These nerves contain C1 fibres distributed *via* the hypoglossal.

The descendens hypoglossi is given off below the origin of the occipital artery, it runs inferiorly on the anterior aspect of the carotid sheath posterolateral to the superior thyroid artery. It may be inside (Cunningham, 1967), outside (Bruce *et al.*, 1964), or in the carotid sheath (Gray, 1980). Below the oblique line of the thyroid cartilage it is closely related to the thyroid apex (Quaine, 1923; Cunningham, 1967). The thyrohyoid branch leaves the hypoglossal just before this nerve goes deep to the posterior belly of the digastric muscle. The geniohyoid branch is given off above this level.

The nerves to the infrahyoid muscles are derived from the ansa cervicalis which has two roots: the descendens hypoglossi carrying C1 fibres, forms the superior root; and the fibres from C2, C3 form the inferior root. The usual textbook description is that these muscles are innervated direct from the ansa except the thyrohyoid.

The ansa cervicalis can show variations. The level at which it is formed shows differences (Last, 1978). It is usually situated deep to the intermediate tendon of the omohyoid muscle at cricoid cartilage level but may be higher or lower. The mode of formation may be a loop but often the two roots unite high up in the shape of a Y and form a single stem from which are given off the segmental infrahyoid nerves (Last, 1978). The inferior root contains C2, C3 fibres but may have C1 or even C4 filaments (Gray, 1980). In its course the inferior root, also called descendens cervicalis, may be placed anterolateral or posteromedial to the internal jugular vein (Grant, 1956). Variations of the ansa cervicalis have also been described in the dog (Benson and Fletcher, 1971).

*Thyroid vessels*

The superior thyroid artery is a branch of the external carotid. Sometimes it arises from the carotid sinus (Gray, 1980) or even the internal carotid (Menasche *et al.*, 1976). It has muscular, laryngeal and glandular branches. These latter reach the apex of the thyroid to divide into anterior, anastomotic and posterior branches, the anastomotic branch being placed on the upper border of the thyroid isthmus. Occasionally a lateral branch is present (Gray, 1980; Grant, 1980).

The cricothyroid artery, which arises from the superior thyroid artery or its anterior branch, runs across the upper border of the cricothyroid muscle and cricothyroid membrane. It supplies nearby structures and sends small branches into the larynx (Grant, 1980). It ends by communicating with the artery of the opposite side or it may pierce the cricothyroid membrane to end inside the larynx (Quain, 1822). In a small percentage of subjects it has been reported as being absent (Durham and Harrison, 1964). Its course may be deep or superficial to the insertion of the sternothyroid muscle (Grant, 1980; Jamieson, 1975). When this artery is placed superficially (Durham and Harrison, 1964) it is found in the plane between the sternohyoid and sternothyroid muscles; when placed deep, it is in the same plane as the external laryngeal nerve.

In addition to the superior thyroid branches the thyroid gland is supplied by the inferior thyroid arteries and sometimes the thyroidea ima; the right lobe having the richer supply (Paparella and Shumrick, 1980). There are many anastomotic vessels (Ajao, 1979) coming from nearby organs (Irvine, 1965; Smith, 1961), to which the ascending pharyngeal and bronchial arteries contribute (Smith, 1961). This vascularity may increase with medication (Micks, 1951; Smith, 1961) and is well seen in the enlarged hyperactive gland. The lingual artery has been described as sending a branch (Cloquet, 1828).

The superior thyroid vein is placed lateral to the artery. It drains into the internal jugular vein or the common facial. The middle and inferior thyroid veins drain into the internal jugular and brachiocephalic, respectively.

**Dissection**

Fifteen subjects were examined, eight female and seven male, representing 30 specimens. Of these, three were dissected on the right side in detail, permanent records being obtained in these three specimens selectively numbered one, two, three. The external laryngeal nerve was examined in 21 specimens, ten on the right side and eleven on the left side. The cricothyroid artery was examined in 29 specimens, fifteen on the right side and fourteen on the left. There were two reasons for not including all the specimens: first, the subjects are required for teaching purposes in the Department of Anatomy, consequently damage to anatomic structures does occur; secondly, during embalming instead of the femoral and radial arteries, the carotids are occasionally used. The leakage which apparently occurred during the procedure in some of these subjects made tissues unsuitable for fine dissection. For these reasons damaged specimens were excluded; of the nine, four were male and five female.

*Cricothyroid artery*

As has been mentioned, the cricothyroid artery pursues a course superficial or deep to the insertion of the sternothyroid muscle. Of the 29 specimens examined the proportions were as follows:

On the left side, eight were placed superficially and six deep. On the right side, these figures were seven and three respectively. A further five specimens on the right side had both superficial and deep branches. The variable course of the artery is confirmed (Grant, 1980; Jamieson, 1975). A right-sided preponderance of superficially placed branches following the oblique line of the thyroid cartilage is noted.

*External laryngeal nerve*

Of the 21 specimens examined, the external laryngeal nerve was found to be situated deep to the insertion of the sternothyroid muscle in all. In one instance only, in specimen number one, was there demonstrable evidence of a fine communication between the external laryngeal and the nerve filaments accompanying a superficially placed cricothyroid artery (Sow *et al.*, 1982; Grant, 1956; Visset *et al.*, 1975).

*Ansa cervicalis*

*In specimen number one,* branches to the superior belly of the omohyoid, the sternothyroid and possibly the cricothyroid proceeded from a network of nerves situated superficial to the thyrohyoid muscle. A nerve arising from the hypoglossal and following the superior thyroid artery and its superficial cricothyroid branch joined the network. The communicating branch has been alluded to in the last paragraph. The internal laryngeal, external laryngeal, desendens hypoglossi and recurrent laryngeal nerves were identified in their usual course.

*In specimen number two,* the sternohyoid and sternothyroid were supplied by a nerve one millimetre in diameter which arose direct from the hypoglossal. This nerve pursued a superficial course in very close proximity to the superior thyroid artery and its superficial cricothyroid branch, thereafter innervating the deep surface of the sternohyoid and superficial surface of the sternothyroid. A further branch placed on the cricothyroid muscle was, on fine dissection, noted to be proceeding to the isthmus of the thyroid gland (Quain, 1839; Visset *et al.*, 1975). A relatively large external laryngeal nerve was placed deep to the superior thyroid artery and to the sternothyroid muscle. The descendens hypoglossi, a completely separate nerve, joined the inferior root and formed the ansa cervicalis at the level of the omohyoid tendon. A common trunk thus formed descended direct to the suprasternal notch between the sternothyroid and sternohyoid close to their outer borders and innervated these muscles at their level of origin. The recurrent laryngeal was placed in its normal course, as was the internal laryngeal.

*In specimen number three,* a fine network placed superficial to the oblique line gave filaments to the sternothyroid and possibly the cricothyroid muscle. The sternohyoid and superior belly of the omohyoid crossed this area superficially. A nerve leaving the thyrohyoid branch of the hypoglossal and accompanying the superior thyroid artery joined the network. The cut stump of a distinct and separate descendens hypoglossi was noted. The internal laryngeal, external laryngeal and recurrent laryngeal nerves were also identified.

The foregoing details are based on the fifteen subjects examined. Subsequent to these an examination on both sides of the neck of a previously undissected male subject demonstrated clearly the segmental nature of the ansa cervicalis. The sternohyoid was innervated by branches above, the other below the cricoid cartilage (Anson, 1966; Woodburne, 1969). The upper branch followed the oblique line of the thyroid cartilage, and it accompanied a small-calibre superficial cricothyroid artery. The lower branch was placed at a level below the cricoid cartilage. Both were given off from the ansa cervicalis, the lower branch arising from its inferior stem. The descendens hypoglossi was placed close to the apex of the thyroid gland. Another fine nerve, separate from the above, was noted accompanying the superior thyroid artery and then a branch of the sternocleidomastoid artery to supply the superior belly of the omohyoid at oblique line level. Its origin was not traced.

**Discussion and principal findings**

Complementing this information with that obtained from the available literature the following conclusions are reached:

—The course of the cricothyroid artery (Fig. 4) is variable, with a greater number placed superficial to the sternothyroid muscle. This superficial branch may have a very small calibre, in which case it can be missed if not looked for carefully and it may be recorded as being absent.

—The external laryngeal nerve (Fig. 5) takes a course deep to the sternothyroid muscle very closely related to the superior thyroid vessels.

—The possibility that the cricothyroid muscle receives filaments taking a superficial course was not shown conclusively. Further



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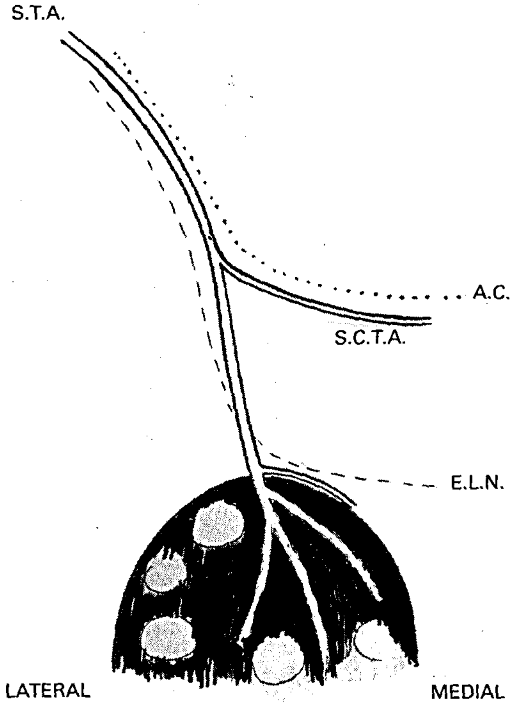


FIG. 4

Superficial cricothyroid artery with branch of ansa cervicalis. Superior thyroid artery with external laryngeal nerve.

study, using subjects specially prepared for the purpose, can elucidate this point.

—The infrahyoid muscles are innervated above cricoid cartilage level in addition to low innervation. In the case of the sternohyoid, a nerve enters its deep surface at the level of the oblique line of the thyroid cartilage.

—The ansa cervicalis can show many variations.

—The nerves to the infrahyoid muscles can arise direct from the hypoglossal or from its thyrohyoid branch, in which case these nerves accompany the superior thyroid artery and its superficial cricothyroid branch.

—A publication relates laryngeal function to the hypoglossal nerve (Gonzales-Baron, 1979). Experimental section of this nerve immediately below the posterior belly of the digastric muscle can apparently result in functional changes of the larynx. Whether this is secondary to the effects of tongue paralysis or a result of direct laryngeal involvement is not clear. If the latter be the case, it is possible that C1 fibres contained in the hypoglossal are involved. The geniohyoid, a suprahyoid muscle, and the infrahyoid muscles are innervated wholly or partially by the first cervical nerve (Quaine, 1923; Spalteholz, 1903). One textbook refers to an experiment in which the action of an extrinsic muscle, the sternothyroid, was tested; a consequent voice change related to head position was noted. The test was apparently carried out while the patient sang a sustained note at the time of thyroidectomy carried out under local analgesia (Paparella and Shumrick, 1980).

—The descendens hypoglossi can be closely related to the apex of the thyroid gland, placed posterolateral to it.

—Sympathetic nerves in the form of a perivascular plexus or fine filaments accompany the superior thyroid artery and its cricothyroid branch (Cunningham, 1981). In the aforementioned dissections it was not possible to identify such filaments conclusively.

**Surgical application**

As to the surgical implications of these statements, the following can be suggested:

—A superficially placed cricothyroid artery which can be of substantial size may require attention when a large isthmus, a thyroglossal cyst or a large pyramidal lobe is being dealt with. Injury to segmental nerves derived from the ansa cervicalis is a possibility in view of their proximity to this artery.

—The external laryngeal nerve is in a vulnerable position near the thyroid apex. Avoidance of damage to it in this area by individual ligation/division of vessels is emphasized. This approach would also preserve branches of the ansa cervicalis.

—Division of the infrahyoid muscles is not always necessary, but is recommended by some as a routine (Sedgwick and Cady, 1980). When not done routinely, its practice appears to be directly proportional to the size of the gland. It has been the experience of the author that, in some communities where goitres are

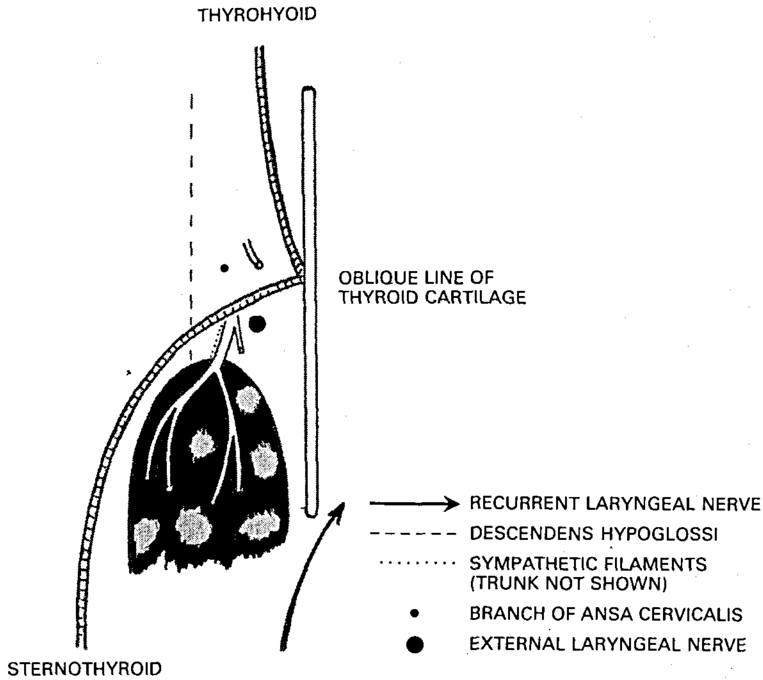


FIG. 5
Nerves: thyroid apex.

endemic, hospital attendance by the patient may be delayed, and the gland can attain a considerable size before the patient comes to surgery. Thyroidectomy in these patients will be facilitated by division of the infrahyoid muscles. This also allows for a proper visualization of the upper pole.

—Precise details are lacking in surgical textbooks as to where the infrahyoid muscles should be divided. Most recommend 'high' transection (Paparella and Shumrick, 1980; Farquharson and Rintoul, 1972; Schwartz *et al.*, 1979). Others recommend division in the middle of the exposed length (Wilson, 1962), and one textbook advises low section in the neck (Stell and Maran, 1978). The optimum site for transection of the sternohyoid and sternothyroid should be just below cricoid cartilage level, parallel to the lower extremity of the oblique line of the thyroid cartilage, in this way minimizing the risk of damage to the higher segmental nerves arising from the ansa cervicalis.

—Because low innervation of the strap muscles is emphasized in surgical textbooks, the fact that there is a higher innervation is overlooked; thus, damage to these nerves at a 'high' transection is a possibility.

—During transection the lowest branch of the ansa cervicalis, which innervates the sternohyoid and sternothyroid, is in a vulnerable position as it proceeds inferiorly towards the sternoclavicular junction. Division of the strap muscles to the carotid sheath (Bailey and Love, 1981), as is sometimes recommended, will not necessarily avoid damage to a more medially placed nerve. Likelihood of injury increases as the incision is carried laterally in the sternothyroid muscle, the outer border of which is placed near the carotid sheath and the nerve. Full transection of this muscle is therefore not recommended unless the nerve is identified and avoided.

—When transecting the sternohyoid it is necessary to bear in mind that the muscle can blend with the superior belly of the omohyoid, forming a single muscular sheath. The ansa lies deep to the intermediate tendon of the omohyoid and becomes vulnerable when the incision is inadvertently or deliberately (Sedgwick and Cady, 1980) extended into the omohyoid. The medial border of the sternocleidomastoid muscle usually overlies this junction, which can act as a rough guide to the limit of division.

—In view of the closeness of the descendens hypoglossi to the thyroid apex, particularly when this nerve is placed outside the carotid sheath, mass ligation of vessels may involve this nerve.

—Division of sympathetic nerves accompanying the superior thyroid artery is inevitable but apparently harmless. The same cannot be said for the sympathetic trunk. Injury to this nerve next to the thyroid apex is unlikely; nevertheless, the possibility should be borne in mind.

—Post-operative voice change is often attributed to recurrent laryngeal nerve injury, but cricothyroid muscle paralysis, the result of external laryngeal nerve damage (Kark *et al.*, 1984) or direct muscle injury, is another possible cause. Ansa cervicalis injury dennervating the strap muscles or direct strap muscle injury (Kark *et al.*, 1984) by division/retraction can be another factor. Tracheal distortion should be ruled out before attributing voice change to nerve injury (Oliech, 1979). Similarly, voice change due to endotracheal intubation needs to be considered (Kark *et al.*, 1984).

## Conclusion

Undoubtedly it is the recurrent laryngeal nerve, not discussed in this article, to which attention should be directed during thyroidectomy. The consequences of harming it need not be detailed here. Damage to the external laryngeal nerve before or during surgery produces voice changes which may be temporary or permanent (Sabiston, 1986; Harries, 1955). Injury to the sympathetic trunk, though a rare occurrence, will result in pseudoptosis and myosis (Kyle and Hardy, 1981; Reeve *et al.*, 1969; Aird, 1957). As to the ansa cervicalis and its branches, long established surgical teaching has advocated techniques of exposure, the purpose of which is to minimize the amount of infrahyoid muscle paralysed by preserving the inferior branches of the ansa. The same reasoning should be applied to the higher segmental nerves innervating these muscles. These higher branches have been overlooked in the surgical literature. There is no information in general surgical textbooks about the functional changes accompanying the denervation of these muscles. The likelihood that deglutition, mastication and speech may in some way be modified can be correct but the extent to which this occurs in a surgical patient and whether it is of any clinical significance requires elaboration with a study of muscle function (Basmajian and De Luca, 1985; Faaborg-Andersen and Sonninen, 1960) and voice production (Kark *et al.*, 1984) in patients undergoing thyroidectomy.

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## References

Aird, I. (1957) *A Companion to Surgical Studies.* 2nd Ed. Livingstone, Edinburgh.

Ajao, O. G. (1979) Thyroidectomy under local anaesthesia. *Tropical Doctor,* April, pp. 73–75.
Anderson, W. A. D. (1964) *Synopsis of Pathology.* 6th Ed. Mosby, St. Louis.
Anson, Barry J. (1966) Morris' Human Anatomy. 12th Ed. McGraw Hill Book Company, New York.
Bailey, H. and Love, McN. (1981) *Short Practice of Surgery* (Harding Rains, A. J., Ritchie, H. D. eds). 18th Ed. H. K. Lewis, London.
Basmajian, J. V. and De Luca, Carlo J. (1985) *Muscles Alive.* 5th Ed. Williams and Wilkins, Baltimore.
Benson, R. O. and Fletcher, T. F. (1971) Variability of the ansa cervicalis in dogs. *American Journal of Veterinary Research,* **32:** 1165–1168.
Bruce, J., Walmsley, R. and Ross, J. A. (1964) *Manual of Surgical Anatomy.* Livingstone, Edinburgh.
Buchanan, A. M. *Manual of Anatomy* (1949) (Jones, W. F. ed.). 8th Ed. Baillière Tindall Cox, London.
Cloquet, J. (1828) *Angiologie, Anatomie De L'Homme.* Engelmann, Paris.
Conroy, R. T. W. L. and Mills, J. N. (1970) *Human Circadian Rhythms.* Churchill, London.
Cunningham, D. J. (1967) *Manual of Practical Anatomy* (Romanes, G. J. ed.). 13th Ed. Vol. 3. Oxford University Press, London.
Cunningham, D. J. (1981) *Textbook of Anatomy* (Romanes, G. J. ed.). 12th Ed. Oxford University Press, Oxford.
Das, K. (1968) *Clinical Methods in Surgery.* 8th Ed. S. K. Dhar, Calcutta.
Davidson, S. (1967) *The Principles and Practice of Medicine.* 8th Ed. Livingstone, Edinburgh.
Du Plessis, D. J. (1975) *A Synopsis of Surgical Anatomy.* 11th Ed. John Wright, Bristol.
Durham, F. C. and Harrison, T. S. (1964) The surgical anatomy of the superior laryngeal nerve. *Surgery, Gynecology, Obstetrics,* **118:** 38–44.
Ellis, H. (1983) *Clinical Anatomy.* 7th Ed. Blackwell, Oxford.
Faaborg-Andersen, K. and Sonninen, A. (1960) The function of the extrinsic laryngeal muscles at different pitch. *Acta Otolaryngologica (Stockholm),* **51:** 89–93.
Farquharson, E. L. and Rintoul, R. F. (1972) *Textbook of Operative Surgery.* 5th Ed. Churchill Livingstone, Edinburgh.
Gannong, W. F. (1969) *Review of Medical Physiology.* 4th Ed. Lange Medical, Los Altos.
González-Barón, S., Molina, M., Garcia-Matilla, F. and Bogas, A. (1979) Influences of hypoglossus and glossopharyngeus nerves on the larynx resistance. *Revista Española De Fisiologia,* **35:** 251–254.
Grant, J. C. B. (1956) *An Atlas of Anatomy.* 4th Ed. Williams Wilkins, Baltimore.
Grant, J. C. B. (1980) *Method of Anatomy* (Basmajian, J. V. ed.). 10th Ed. Williams Wilkins, Baltimore.
Gray, H. (1980) *Anatomy* (Williams, P. L. and Warwick, R. eds). 36th Ed. Churchill Livingstone, Edinburgh.
Gray, S. W. and Skandalakis, J. E. (1972) *Embryology for Surgeons.* W. B. Saunders, Philadelphia.
Grey Turner, G. (1948) *Modern Operative Surgery.* 3rd Ed. Vol. 1. Cassel, London.
Haines, R. W. and Mohiuddin, A. (1972) *Human Embryology.* 5th Ed. Churchill Livingstone, Edinburgh.
Hamilton, W. J., Simon, G. and Hamilton, S. G. (1971) *Surface and Radiological Anatomy.* 5th Ed. Heffer, Cambridge.
Harries, D. J. (1955) Thyroid enlargement and the crico-thyroid muscle. *British Medical Journal,* **I:** 1012–1013.
Harrison, R. G. (1963) *A Textbook of Human Embryology.* 2nd Ed. Blackwell, Oxford, p. 211.
Henry, A. K. (1970) *Extensile Exposure.* 2nd Ed. Livingstone, Edinburgh.
Hutchinson, J. H. (1967) *Practical Paediatric Problems.* 2nd Ed. Lloyd-Luke, London.
Irvine, W. T. (1965) *The Scientific Basis of Surgery.* J. A. Churchill, London.
Jamieson, E. B. (1975) *A Companion to Manuals of Practical Anatomy.* 7th Ed. Oxford University Press, London.
Johnston, T. B. (1968) *Synopsis of Regional Anatomy* (Warwick, R. ed.). 10th Ed. J. A. Churchill, London.
Kark, A. E., Kissin, M. W., Auerbach, R. and Meikle, Margaret (1984) Voice change after thyroidectomy: role of external laryngeal nerve. *British Medical Journal,* **289:** 1412.
Kyle, J. and Hardy, J. D. (1981) *Scientific Foundations of Surgery.* 3rd Ed. Heinemann, London.
Last, R. J. (1978) *Anatomy, Regional and Applied.* 6th Ed. Churchill Livingstone, Edinburgh.
Menasche, P., Mamoudy, P. and Blondeau, P. (1976) Le nerfe laryngé externe. Danger possible de la chirurgie thyroïdienne. *Annales Chirurgien, France,* **30:** 121–129.
Micks, R. H. (1951) *The Essentials of Materia Medica, Pharmacology and Therapeutics.* 5th Ed. Churchill, London.
Mitchie, W. (1978) Beta-blockers and thyroid function. *British Medical Journal,* **I:** 106–107.
Nixon, H. H. and O'Donnell, B. (1966) *The Essentials of Paediatric Surgery.* 2nd Ed. Heinemann, London.
Nouveau Larousse Médical (1952) Libraire Larousse, Paris.
Oliech, J. (1979) Thyroid enlargement and the trachea. *The Proceedings of the Association of Surgeons of East Africa,* **2:** 216–217.
Paparella, M. M. and Shumrick, D. A. (1980) *Otolaryngology.* 2nd Ed. Vol. 1, 3. W. B. Saunders, Philadelphia.
Quain, J. (1822) *Anatomy of Arteries.* Taylor Walton, London.
Quain, J. (1839) *Nerves of the Human Body.* Quain, J., Wilson, W. J. E.. Taylor Walton, London.
Quain, J. (1923) *Elements of Anatomy. Myology* (Bryce, T. H., ed.). 11th Ed. Vol. 4, Pt 2. Longmans Green, New York.

Reeve, T. S., Coupland, G. A. E., Johnson, D. C. and Buddee, F. W. (1969) The recurrent and external laryngeal nerves in thyroidectomy. *The Medical Journal of Australia,* **1:** 380–382.

Robinson, J. O. (1973) *Rawling's Landmarks and Surface Markings of the Human Body.* 9th Ed. H. K. Lewis, London.

Sabiston, D. C. (1986) *Textbook of Surgery,* 13th Ed., Ch. 24. W. B. Saunders, Philadelphia.

Samson Wright (1982) *Applied Physiology* (Keele, C. A., Neil, E., Joels, N. eds). 13th Ed. Oxford University Press, Oxford.

Schwartz, S. I., Shires, G. T., Spencer, F. C. and Storer, E. H. (1979) *Principles of Surgery.* 3rd Ed. Vol. 2, Ch. 38. McGraw Hill, New York.

Scott-Brown, W. G. (1979) *Diseases of the Ear, Nose and Throat* (Ballantyne, J., Groves, J., eds). 4th Ed. Vol. 1 and 4. Butterworths, London.

Sedgwick, C. E. and Cady, B. (1980) *Surgery of the Thyroid and Parathyroid Glands.* Saunders, Philadelphia.

Smith, R. (1961) *Progress in Clinical Surgery,* 2, 6. Churchill, London.

Sow, M. L., Koyalta, M., Benchekroun, A. and Diop, A. (1982) Le nerfe laryngé externe dans le chirurgie d'exérèse thyroïdeine. *Dakar Medical,* **27:** 177–186.

Spalteholz, W. (1903) *Hand Atlas of Human Anatomy.* 3rd Ed. in English., Vols. 2 and 3. Lippincott, Philadelphia.

Stell, P. M. and Maran, A. G. D. (1978) *Head and Neck Surgery.* 2nd Ed. W. Heinemann, London.

Sutton, D. (1980) *A Textbook of Radiology and Imaging.* 3rd Ed. Churchill Livingstone, Edinburgh.

Sweet, R. H. (1949) Intrathoracic goiter located in the Posterior Mediastinum. *Surgery, Gynecology and Obstetrics,* **89:** 57–66.

Visset, J., Leborgne, J. and Barbin, J.-Y. (1975) Le nerfe laryngé externe. *Bulletine Association Anatomical, Virret, Nancy,* **59:** 1001–1012.

Wilson, T. G. (1962) *Diseases of the Ear, Nose and Throat in Children.* 2nd Ed. William Heinemann, London.

Woodburne, R. (1969) *Essentials of Human Anatomy.* 4th Ed. Oxford University Press, New York.

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