The Journal of Laryngology & Otology (2007), ***121***, *1118–1125.*
© 2007 JLO (1984) Limited
doi:10.1017/S0022215107000461
Printed in the United Kingdom
First published online 25 September 2007

Review Article

Accessory nerve: anatomy and surgical identification

S Lloyd

Abstract

The XIth cranial nerve or accessory nerve provides the motor supply to the sternocleidomastoid and trapezius muscles. It is frequently encountered during neck surgery, and as such is at risk of iatrogenic injury, resulting in the 'shoulder syndrome'. Historically, the nerve was sacrificed on oncological grounds during radical neck dissection. However, the basis for sacrifice is unfounded in the majority of cases, and accessory nerve sparing selective neck dissection has equal oncological efficacy. The path of the nerve in the neck is very variable, and there is not a wholly reliable landmark for its identification. However, there are a number of methods described in the literature to guide the surgeon in its identification. This paper provides a systematic review of all the methods available for identification of the accessory nerve, and comments on the reliability of each. In doing so, the detailed anatomy of the accessory nerve is also described.

Key words: Accessory Nerve; Eleventh Cranial Nerve; Anatomy

Introduction

Radical neck dissection was first described by George Crile in 1906,[1] and initially involved removal of the internal jugular vein and its associated lymphatics. In Crile's description, the sternocleidomastoid muscle was removed to improve exposure. Subsequently, the technique was modified to involve en bloc removal of the spinal accessory nerve and the lymphatics of the posterior triangle, on the premise that to remove less would compromise the patient oncologically. However, there is strong evidence that preservation of the spinal accessory nerve throughout its course does not compromise the patient in this way, assuming that there is not disease adjacent to the nerve. This has resulted in the introduction of numerous modifications to the technique in order to improve morbidity following surgery. Dargent and Papillon, in 1945, were the first to propose preservation of the spinal accessory nerve in certain cases.[2] Selective neck dissection was first described by Suarez in 1963.[3] This concept, in which all the functionally important structures within the neck are preserved, was further expounded by Bocca *et al.*[4,5] All such operations aim to preserve the spinal accessory nerve.

There are a number of large series in the literature confirming that the recurrence rate following selective neck dissection is not higher than that following radical neck dissection.[6–12] However, in many of these studies, the use of radical radiotherapy as an adjunct to selective neck dissection may have skewed the results. In addition, most of the studies were not matched in terms of pre-operative neck stage. Interestingly, Roy and Beahrs found that, even with positive nodes in the neck, the use of selective neck dissection did not result in a relative increase in recurrence rates, compared with radical neck dissection.[12] It should be noted that there is a high proportion of microscopically positive lymph nodes adjacent to the spinal accessory nerve as it passes through the anterior triangle (∼40 per cent).[13] This contrasts with the portion of the spinal accessory nerve in the posterior triangle, where adjacent nodal involvement is unusual.[14–16] (Ninety per cent of involved nodes adjacent to the spinal accessory nerve are in the anterior triangle.[14]) A number of authors have also commented that it seems counter-intuitive that the hypoglossal, lingual, vagus and phrenic nerves may all be preserved without compromising the resection (as they are in radical neck dissection) but the spinal accessory nerve may not.

The spinal accessory nerve provides the motor supply to the sternocleidomastoid and trapezius muscles. Sacrifice of the spinal accessory nerve usually causes the 'shoulder syndrome'.[17] This results from weakness of the trapezius muscle, with resultant drooping of the shoulder and prominence of the scapula. The strain that this places on the remaining functional shoulder muscles, namely the levator scapulae and the rhomboids, results in pain. In addition, as one would expect, there is an inability

From the Whipps Cross University Hospital, Whipps Cross Road, Leytonstone, London E11 1NR, UK.
Accepted for publication: 1 June 2007.

https://doi.org/10.1017/S0022215107000461 Published online by Cambridge University Press

to abduct the arm beyond 90°. A 'frozen shoulder' may result from a secondary periarthritis.

It is interesting to note that not all patients who undergo sacrifice of the accessory nerve will develop shoulder syndrome; conversely, not all patients with preservation of the nerve are symptom free. This latter situation may reflect unrealised damage to the spinal accessory nerve (see below). There are several papers presenting shoulder outcomes following surgery. Saunders *et al.* describe the shoulder outcomes of 146 neck dissections.[15] Ninety-three per cent of patients with spinal accessory nerve preservation had mild or no symptoms, and 71 per cent retained good trapezius function. Of those undergoing spinal accessory nerve sacrifice, 67 per cent had mild or no symptoms, although 67 per cent had no trapezius function. A proportion of these authors' patients had adjuvant radiotherapy, which may have affected outcome. The innervation of the trapezius is controversial and will be discussed in more detail below.

This review will discuss in detail the anatomy of the accessory nerve, from its exit from the spinal cord and brainstem to its termination at the trapezius. The numerous methods of identification of the accessory nerve will then be presented. Throughout the text, studies performed on cadavers and on live patients have been differentiated by the letters 'C' and 'L', respectively. This will enable readers to make allowances for the potential drawbacks of studies using cadaveric specimens, namely, the possibility of artefact resulting from the fixation process.

Methods

A systematic review of the literature was performed by searching the Medline, Embase, Cinahl and Cochrane Library electronic databases (from inception to November 2006). Key texts relevant to the subject field were also hand-searched. A literature search in Medline (using Medical Subject Headings) and Embase (using EMTREE) used the following subject headings: 'accessory nerve' and 'anatomy'. The following additional keywords were also used in all databases: '11th cranial nerve', 'eleventh cranial nerve', 'surgical identification', 'surgical recognition' and 'surgical location', with variants of the main words. Full papers for each study were reviewed. Inclusion criteria included English language studies and human studies. Exclusion criteria included papers not published in peer-reviewed journals.

Anatomy

The accessory nerve is the XIth cranial nerve and is formed from two roots, a cranial root and a spinal root.[18,19] The cranial root originates from the vagal nuclei and, like the vagus nerve (which it eventually joins), it supplies some of the muscles of the soft palate and larynx. The spinal root originates from the spinal accessory nucleus within the upper five cervical segments of the spinal cord. As already discussed, it provides motor innervation to the sternocleidomastoid and trapezius muscles. Damage to this portion of the nerve is much more common, and more clinically important, than damage to the cranial portion.

Intracranial anatomy

The cranial root of the accessory nerve usually passes out of the brainstem lateral to the olive as a number of rootlets, and becomes a single trunk which passes to the jugular foramen.[18,19] However, this does not always occur, and the rootlets may pass to the jugular foramen without merging. It is occasionally difficult to differentiate these cranial accessory rootlets from the rootlets of the vagus nerve which leave the brainstem just cranial to the cranial accessory rootlets. In fact, it is reasonably common for the caudal vagal rootlets and the cranial accessory rootlets to enter the jugular foramen as a single unit.[20C] These cranial rootlets of the accessory nerve should more properly be regarded as inferior vagal rootlets, since they arise from vagal nuclei.[20C,21C]

The spinal root emerges from the cervical spinal cord as a number of rootlets between the anterior and posterior nerve roots of the cervical spinal nerves. The fibres merge to form a trunk that ascends into the skull through the foramen magnum. The spinal root then passes laterally towards the cranial root.[18,19]

In the majority, the roots join and pass into the jugular foramen as a single trunk. However, in some individuals, the nerves enter the foramen as separate roots. In those who have a single trunk, the spinal part separates from the cranial part within the foramen and the cranial part merges with the vagus nerve.[18,19] The accessory nerve distal to this point consists purely of fibres from the spinal nucleus.

Jugular foramen

The jugular foramen is an irregular foramen in the lateral skull base, the walls of which are the temporal bone anterolaterally and the occipital bone posteromedially. It is divided into three compartments by two transverse septa formed from the inner layer of dura.[18,19] These septa are usually fibrous, but may be bony in up to 36 per cent of individuals.[20C] The anterior compartment has a funnel-shaped meatus into which pass the glossopharyngeal nerve and the inferior petrosal sinus. The glossopharyngeal ganglion is situated within the foramen. The posterior compartment contains the termination of the sigmoid sinus as it drains into the jugular bulb. The inferior petrosal sinus passes posteriorly within the jugular foramen to enter the medial wall of the jugular bulb.[20C]

The middle compartment has a shallower meatus which is approximately twice the width of the anterior compartment, and through which pass the vagus and accessory nerves. In those individuals who have separate cranial and spinal roots of the accessory nerve, there may be an additional fibrous septum that separates the roots.[20C] The accessory nerve descends through the foramen lateral to the vagus nerve.[19] The superior portion of the superior vagal ganglion is situated within the foramen.

https://doi.org/10.1017/S0022215107000461 Published online by Cambridge University Press

Anterior triangle

Following its exit from the jugular foramen, most papers describe the spinal accessory nerve passing medial or lateral to the internal jugular vein. The lateral course is more common than the medial course, but the reported incidences of each vary widely in the literature.[22C,23C,24C] Rarely, the spinal accessory nerve may pass through the vein.[25L,26L] However, Kierner *et al.* describe the spinal accessory nerve as passing anterior to the vein in around 60 per cent of cases and posterior to it in around 40 per cent.[27C] The nerve then crosses the transverse process of the atlas and is itself crossed by the occipital artery.[18] It descends obliquely, medial to the styloid process, stylohyoid and digastric. The spinal accessory nerve then passes into (70–80 per cent) or under (20–30 per cent) the sternocleidomastoid.[27C,28C] It is in close proximity to the sternocleidomastoid branch of the occipital artery as it passes into the muscle.[29C]

Entry into the muscle is between the cleidomastoid portion of the muscle, which lies deep to the nerve, and the sternomastoid and sternocleido-occipitalis portions of the muscle, which lies superficial to the nerve.[28C] The point of entry of the spinal accessory nerve into the sternocleidomastoid ranges between 3.2 and 4.7 cm from the mastoid process.[28C,30C] Most authors describe a straight path through the muscle;[31C] however, Kierner *et al.* describe a three-dimensional, s-shaped course.[27C] In a cadaveric study by Soo *et al.*, one of the specimens examined had a spinal accessory nerve which divided in the anterior triangle into three branches, each of which passed individually to the sternocleidomastoid, trapezius and the cervical plexus. Interestingly, in this specimen, the spinal accessory nerve entered the posterior triangle near its apex and passed down the anterior border of the trapezius for some distance prior to passing under the muscle.[22C] A similar high division of the spinal accessory nerve has been described by Bater *et al.*[32L] Within the muscle, the spinal accessory nerve receives contributions from the cervical plexus (C2 alone or C2 and C3)[22C,30C] forming the ansa of Maubrac. It also gives off one to four branches which provide motor innervation to the sternocleidomastoid.[28C]

Posterior triangle

The spinal accessory nerve then exits the posterior border of the sternocleidomastoid at the junction of the upper third and lower two-thirds.[33L] The exact position is variable but is usually 7–9 cm from the clavicle, along the posterior border of the sternocleidomastoid.[27C] In a cadaveric study by Lu *et al.*, this distance ranged from 5.7 to 12.9 cm.[34C] The point of exit has also been measured as 5–7 cm from the mastoid process.[28C,35C] Tubbs *et al.* also measured the distance from the angle of the mandible to the point of exit of the spinal accessory nerve;[35C] the mean distance was 6 cm, with a range of 4.5–7 cm. This distance will clearly be very variable in patients due to the mobility of the mandible. Around 75 per cent have different exit points on each side.[27C]

The relationship between the spinal accessory nerve and the greater auricular nerve is one of the most reliable, and is often used for the surgical identification of the spinal accessory nerve (see below). The point at which the greater auricular nerve crosses the posterior border of the sternocleidomastoid is called the greater auricular point. It is often referred to as Erb's point. However, this is a misnomer, as Erb's point is actually the surface marking of the upper trunk of the brachial plexus and is not the same as the greater auricular point. The Erbs point is found two fingers' breadth above the clavicle and one finger's breadth lateral to the posterior border of the sternocleidomastoid.[36C] In a surgical study by Hone *et al.*, the spinal accessory nerve was always located just above the greater auricular point. The mean distance from the greater auricular point was 10.7 mm, with a range of 3–29 mm.[37L] Soo and colleagues found that in 88 per cent of cases the spinal accessory nerve passed within 2 cm of the greater auricular point but may be up to 4 cm distant.[22C] Hill and Olsen state that the spinal accessory nerve exits the muscle 1–2 cm above the greater auricular point, although their series was extremely small.[29C] Dailiana *et al.* state that the spinal accessory nerve leaves the muscle at the same level as the greater auricular point.[28C]

It should be noted that in some cases the minor occipital nerve enters the posterior triangle at the posterior border of the sternocleidomastoid, about 1–2 cm caudal to the spinal accessory nerve. It then runs parallel to the spinal accessory nerve, and eventually turns upwards in the lateral part of the posterior triangle to cross the spinal accessory nerve. It may be mistaken for the spinal accessory nerve, but may be differentiated from it by its failure to pass under the trapezius.[27C]

One further landmark for the spinal accessory nerve as it leaves the posterior border of the sternocleidomastoid is the ratio between the distance of the exit point of the spinal accessory nerve from the sternocleidomastoid, as measured from the mastoid process, relative to the length of the sternocleidomastoid. This ratio varies between 0.1 and 0.6, but falls below 0.5 in the vast majority of cases, suggesting that the spinal accessory nerve almost always leaves the sternocleidomastoid within the top half of the muscle.[22C] This does not provide a reliable landmark for identification of the nerve.

The spinal accessory nerve then passes posteriorly and inferiorly across the posterior triangle deep to the investing layer of the deep cervical fascia, on the levator scapulae but separated from it by the prevertebral layer of deep cervical fascia and adipose tissue.[18] It is relatively superficial in this position, especially more proximally, and is easily damaged during neck surgery. It is in close proximity to the superficial cervical lymph nodes along its course through the posterior triangle.

There is a small branch from the spinal accessory nerve, approximately 2 cm medial to the anterior

https://doi.org/10.1017/S0022215107000461 Published online by Cambridge University Press

border of the trapezius. This branch enters the descending portion of the muscle approximately 2–3 cm cranial to the point at which the main trunk enters the muscle.[27C,28C,38C] It has been noted intra-operatively by a number of authors, particularly in the plastic surgical literature.[28C,39L,40L] Electromyographic work by Kierner *et al.* on patients undergoing neck dissection has confirmed that this branch is the main motor supply to the descending portion of the muscle, whilst the transverse and ascending portions are supplied by the main trunk of the spinal accessory nerve.[41L] Failure to recognise this branch may explain some of the cases of trapezius paresis occurring despite preservation of the main nerve trunk.

The innervation of the trapezius is controversial. Some authors suggest that the muscle is dually innervated by both the cervical nerves and the spinal accessory nerve.[42L,43C] However, the evidence for this is weak, and it is more likely that the motor supply of the muscle comes partially from the cervical nerves but predominantly from the spinal accessory nerve. Brown *et al.* suggest that innervation of the trapezius involves a spectrum of different combinations of spinal accessory nerve and cervical nerves in different individuals.[33L] A further paper by Soo *et al.* suggests that division of the spinal accessory nerve with preservation of the cervical branches to the trapezius results in a clinical picture similar to that seen when the spinal accessory nerve and cervical nerves are divided. However, electromyography (EMG) results in these patients were still fairly normal, and stimulation of the cervical nerves resulted in contraction of the trapezius, albeit more weakly.[44L] Division of the spinal accessory nerve and cervical nerves resulted clinically in the shoulder syndrome, and EMG studies confirmed at least partial denervation of the muscle. The residual EMG activity observed in these patients raises the issue of whether there is an as yet unknown additional nerve supply to the trapezius, possibly from the thoracic nerves. This may explain why some patients who have had radical neck surgery have unexpectedly few symptoms. Division of the cervical nerves and not the spinal accessory nerve resulted in only mild muscle wasting and mild EMG abnormalities suggesting partial denervation in some patients. It should be noted that EMG does have limitations, and interpretation of results should bear this in mind. Some authors, particularly Kierner *et al.*, argue that the cervical plexus does not contribute significantly to the muscle's motor supply.[41L] Weitz *et al.* have described the sacrifice of the anterior triangle portion of the spinal accessory nerve (the portion often related to positive lymph nodes), with preservation of the distal spinal accessory nerve and the cervical branches in order to preserve trapezius function.[42L] This principle is based on the unconfirmed assumption that the whole trapezius is supplied by both the spinal accessory nerve and the cervical plexus. In addition, these authors did not provide any evidence for the effectiveness of this technique in preserving shoulder function. The presence of a cervical nerve supply of some sort to the trapezius is, however, not in question. It may be that these nerves are predominantly proprioceptive in nature.[18]

The relationship between the cervical nerves and spinal accessory nerve in the posterior triangle varies between papers. Some authors report that there are no anastomoses in the posterior triangle.[27C] However, others report that the spinal accessory nerve and the cervical nerves (C3–4 or C4 alone) form a plexus prior to entering the deep surface of the muscle.[22C] In any event, they do merge on the ventral surface of the muscle and appear to jointly supply the transverse and ascending portions of the muscle.[38C]

The number of cervical branches passing directly to the trapezius varies considerably in the literature. Dailiana *et al.* suggest that such branches are only present in 25 per cent of cases.[28C] In contrast, Kierner *et al.* report that cervical branches supplying the trapezius directly occur in most cases.[27C] These authors state that around 10 per cent of cases have a single cervical nerve branch to the trapezius within the posterior triangle. Around 60 per cent of cases have two branches, 20 per cent of which begin as a single trunk and divide more laterally in the posterior triangle. Thirty per cent have three branches. Of those with two or more branches, one branch passes superficially through the posterior triangle immediately caudal to the spinal accessory nerve. The other, larger branch runs deeper and more caudally.

The spinal accessory nerve passes under the anterior border of the trapezius at a variable point. Soo and colleagues' work on cadavers suggests that an entry point 2–4 cm above the clavicle is by far the most common, although this distance may be as much as 7 cm.[22C] Hone and colleagues' work on operative cases suggests that the spinal accessory nerve passes under the trapezius at a mean distance of 51 mm above the clavicle, but the reported range is 31–99 mm.[37L] Eisele *et al.* suggest that the point at which the nerve passes under the trapezius is 3–5 cm above the clavicle; however, they provide no data to support this measurement.[45C] Dailiana *et al.* measured the distance of the point at which the spinal accessory nerve passes under the trapezius from the midpoint of the clavicle.[28C] The mean distance was 5.2 cm, with a range of 4.8–7 cm. The same measurement in the paper by Tubbs *et al.* was 6 cm, with a range of 5 to 7.5 cm. These authors also measured the distance to the point at which the spinal accessory nerve passed under the trapezius, from a number of other points, including the mastoid tip (6.5–8.5 cm), the acromion of the scapula (5–7 cm) and the posterior border of the sternocleidomastoid (2.5–4 cm) (although the exact point from which this latter measurement was taken is not clear).[35C]

Under the trapezius

The spinal accessory nerve descends on the ventral surface of the trapezius, between the muscle and its covering fascia.[46C] The nerve initially runs parallel

https://doi.org/10.1017/S0022215107000461 Published online by Cambridge University Press

and about 2 cm from the anterior border of the muscle. It then turns medially to run parallel to and about 4 cm from the insertion of the muscle into the spine of the scapula.[46C] At the medial end of the spine, the nerve turns caudally and runs with the transverse cervical vessels midway between the vertebral column and the medial border of the scapula, parallel to the latter.[39L] There are three to six branches from the nerve which supply the transverse and ascending portions of the muscle.[47L] Its division into terminal branches occurs around 7 cm below the scapular spine. Anastomosis with the C3–4 branches occurs as the spinal accessory nerve descends under the trapezius.[38C] This usually occurs approximately 3 cm from the entry of the nerve into the fascia of the muscle.[46C] It should be noted that the course of the nerve deep to the trapezius is dependent on the position of the arm. In adduction, its course is said to be question mark shaped. In abduction, the course of the nerve is straighter.[46C]

Surgical identification

Posterior triangle

Probably the most widely used landmark for identifying the spinal accessory nerve is its relationship to the greater auricular point, although there are surprisingly few surgical papers discussing this.[37L,48L,49L] Hone and colleagues' study included 18 patients undergoing selective neck dissection, and concluded that the greater auricular point was a more reliable landmark than the distance from the clavicle to the point at which the spinal accessory nerve passes under the trapezius.[37L]

Becker and Parell advocate the use of the cervical nerves emerging from the posterior border of the sternocleidomastoid in order to identify the spinal accessory nerve, although they do not specifically mention the greater auricular nerve. They define the surface marking of this point as midway between the mastoid process and the clavicle, referring to this as Erb's point. Their description is confusing and inaccurate. In addition, the paper is purely descriptive and does not contain any data to support their preference.[31L] They do however mention an alternative method of identifying the spinal accessory nerve. They suggest palpating the transverse process of C2 between the mastoid process and the ramus of the mandible. This is facilitated by retracting the angle of the mandible anterosuperiorly. The overlying fascia is carefully incised and the underlying internal jugular vein is identified. The spinal accessory nerve lies either lateral or medial to the vein at this point.

A more accurate method of defining the surface marking of the greater auricular point is described by Baring *et al.*[50L] They suggest drawing a line between the angle of the mandible and the mastoid process and then dropping a second line perpendicular to this from the midpoint of the first line. This line marks the course of the greater auricular nerve as it passes over the sternocleidomastoid.

A number of authors use the point at which the spinal accessory nerve passes under the trapezius as the landmark for identification of the spinal accessory nerve.[6L,27C,45L,48L] In their cadaveric study, Kierner *et al.* suggest this point as the most reliable landmark for identification of the nerve, stating that other landmarks, such as the greater auricular point, are more variable.[27C] However, the literature suggests that the greater auricular point is probably as reliable, if not more so, than the distance from the clavicle. The variability in the distance between the greater auricular point and the spinal accessory nerve is certainly significantly less than that between the clavicle and the entry point of the spinal accessory nerve under the trapezius. Bertelli and Ghizoni use the cervical transverse vessels to aid location of the spinal accessory nerve, explaining that the spinal accessory nerve crosses these vessels at the point at which they pass under the trapezius.[48L] Hattori *et al.* use a similar technique, which involves division of the anterior portion of the insertion of the trapezius from the clavicle and retraction of the muscle to allow identification of the nerve as it descends with the transverse cervical vessels midway between the vertebral column and the medial border of the scapula.[39L]

One interesting paper by Jobe *et al.* discusses the use of a muscle-splitting incision in order to identify the spinal accessory nerve as it passes on the ventral surface of the muscle.[47L] This is not a technique used by head and neck surgeons, but these authors describe the topographical anatomy of the spinal accessory nerve as it passes ventral to the trapezius. They describe the spinal accessory nerve passing caudally in a vertical course, parallel with the vertebral border of the scapula. There were three to six major muscle branches (mean, 3.8). The most lateral branch was located on average 44 per cent of the distance from the spinous process of the vertebrae to the tip of the acromion, and was never more than 50 per cent of the distance. The most medial branch was 33 per cent of this distance. They therefore advocate a muscle splitting incision in the lateral half of the trapezius in order to minimise the risk of damaging the spinal accessory nerve.

A number of studies describe the surface markings of the spinal accessory nerve, although from a surgical perspective these are notoriously unreliable. King and Mott draw a horizontal line from the thyroid notch across the neck; 2 cm above the line delineates the nerve's emergence from the sternocleidomastoid, while 2 cm below the line delineates the nerve's exit into the trapezius.[51L] Salasche *et al.* draw a line from the tip of the mastoid to the angle of the mandible and then drop a perpendicular line at the midpoint. The point at which this line passes across the posterior border of the sternocleidomastoid is said to be the point at which the spinal accessory nerve emerges from the muscle.[52L] This is the same technique described by Baring *et al.*, although they refer to the point at which the line meets the sternocleidomastoid as the greater auricular point rather than the point of exit of the spinal accessory nerve itself. This serves to highlight the fact that all these landmarks are simply an indicator of the position of the spinal accessory nerve and are not wholly accurate or reliable.

https://doi.org/10.1017/S0022215107000461 Published online by Cambridge University Press

Anterior triangle

Two fairly recent papers discuss the use of the sternocleidomastoid branch of the occipital artery as a landmark for the identification of the spinal accessory nerve. The sternocleidomastoid receives blood supply from three perforator arteries which enter the muscle at three separate levels. The most caudal arises from the thyrocervical trunk. The middle vessel arises from the superior thyroid artery and enters the muscle at the level of the omohyoid muscle. The most cranial vessel is the sternocleidomastoid branch of the occipital artery. This latter vessel is fairly large and constant, passing downward and backward over the hypoglossal nerve and entering the muscle in close proximity to the spinal accessory nerve.[18L] A paper by Rafferty *et al.* provides prospective data regarding the nature of this relationship, from 33 selective neck dissections.[53L] The sternocleidomastoid branch of the occipital artery was always superficial and inferior to the spinal accessory nerve. The distance between the sternocleidomastoid branch of the occipital artery and the point of entry of the spinal accessory nerve into the medial aspect of the sternocleidomastoid ranged from 1 to 11 mm in a superior direction; the mean was 6 mm and the median 6 mm. They occasionally found a second, smaller branch running parallel with the main vessel. A paper by Tatla *et al.*, although descriptive in nature, confirms the efficacy of this technique, and adds that the tendinous part of the upper portion of the sternocleidomastoid is a useful landmark for the sternocleidomastoid branch of the occipital artery.[54C]

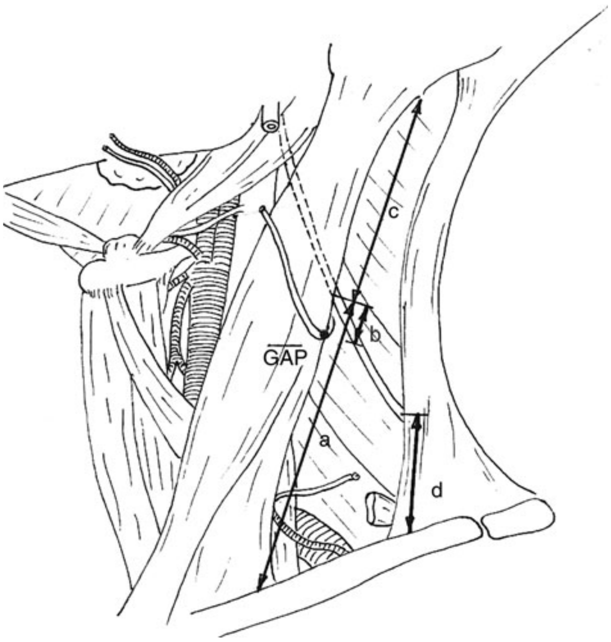

Fig. 1

Diagram illustrating the most useful landmarks for the surgical identification of the spinal accessory nerve (SAN). a = clavicle to SAN along posterior border of sternocleidomastoid (SCM) (57–129 mm); b = greater auricular point to SAN (3–40 mm); c = mastoid tip to SAN along posterior border of SCM (45–70 mm); d = clavicle to SAN along anterior border of trapezius (20–99 mm). (Measurements show the maximum extent of reported variability for each landmark.)

Chaukar *et al.* describe the presence of a small but constant vein at or around the junction of the upper and middle thirds of the sternocleidomastoid in the anterior triangle. This drains the sternocleidomastoid and passes lateral to the spinal accessory nerve, which lies approximately 2 mm deep to it. These authors have found this to be a useful landmark for the spinal accessory nerve.[55L]

Deschler and Singer have described a technique for identifying the spinal accessory nerve at the jugular foramen.[56L] The attachment of the sternocleidomastoid to the mastoid is divided. The posterior belly of the digastric muscle is identified at the angle of the mandible and the muscle is elevated superiorly. The carotid sheath is opened and the internal jugular vein is dissected up to the skull base. Here, the spinal accessory nerve can be identified, usually on the anterolateral aspect of the vein. These authors do not comment on the difficulty of finding the spinal accessory nerve if it passes medial to the vein.

Stearns and Shaheen suggest identifying the spinal accessory nerve as it emerges from the sternocleidomastoid by dividing the sternocleidomastoid into thirds and dissecting at the posterior border of the sternocleidomastoid at the junction of the middle and upper thirds.[57L] They do not describe any specific landmarks, and their technique provides only a very broad indicator of the position of the spinal accessory nerve.

Finally, Fisher advocates the use of serial pinpricks in the posterior triangle to identify the course of the nerve. Hyperaesthesia is said to result from a pinprick over the nerve.[58L]

It is of interest to note that some authors advocate cable grafting of the cut spinal accessory nerve.[15L] In the series published by Saunders *et al.*, nine patients underwent cable grafting with the greater auricular nerve following division of the spinal accessory nerve during neck dissection, and all showed no shoulder symptoms or only mild symptoms. All except one patient retained moderate to good trapezius function.[15L]

Eisele *et al.* suggest that a nerve stimulator may reduce the risk of iatrogenic injury, although they provide no evidence to support this statement.[45L] A case series by Midwinter and Willatt suggests that monitoring of the spinal accessory nerve may be useful, although the study was small and was performed predominantly on patients undergoing lymph node biopsy rather than neck dissection.[59L]

Conclusion

The spinal accessory nerve provides motor innervation to the sternocleidomastoid and trapezius muscles. During neck surgery, it is at risk from iatrogenic trauma, particularly in its course through the posterior triangle. The anatomy of the nerve is very variable, but there are a number of landmarks that make surgical identification easier (Figure 1). In the

https://doi.org/10.1017/S0022215107000461 Published online by Cambridge University Press

posterior triangle, its relationship with the greater auricular nerve is fairly constant and provides one of the most useful landmarks. In the anterior triangle, the relationship of the nerve to the sternocleidomastoid branch of the occipital artery is also useful. Other landmarks are quite variable and identification in these areas may be difficult.

References

1 Crile G. Excision of cancer of the head and neck with special reference to the plan of dissection in 132 operations. *J Am Med Assoc* 1906;**47**:1780–6
2 Dargent M, Papillon J. Motor complications of neck dissection: how to avoid them [in French]. *Lyon Chir* 1945;**40**:718
3 Suarez O. The problem of distant lymphatic metastasis in cancer of the larynx and hypopharynx [in Spanish]. *Rev Otorinolaryngol Santiago* 1963;**23**:83–99
4 Bocca E, Pignataro O, Sasaki CT. Functional neck dissection. A description of operative technique. *Arch Otolaryngol* 1980;**106**:524–7
5 Bocca E, Pignataro O, Oldini C, Cappa C. Functional neck dissection: an evaluation and review of 843 cases. *Laryngoscope* 1984;**94**:942–5
6 Brandenburg JH, Lee CY. The eleventh nerve in radical neck surgery. *Laryngoscope* 1981;**91**:1851–9
7 Byer RM. Modified neck dissection: a study of 967 cases from 1970 to 1980. *Am J Surg* 1985;**150**:414–21
8 Brazilian Head and Neck Cancer Study Group. Results of a prospective trial on elective modified radical neck versus supraomohyoid neck dissection in management of squamous cell carcinoma. *Am J Surg* 1998;**176**:422–7
9 Deutsch EC, Skolnik EM, Friedman M, Hill JH, Sharer K. The conservation neck dissection. *Laryngoscope* 1985;**95**: 561–5
10 Molinari R, Cantu G, Chiesa F, Grandi C. Retrospective comparison of conservation and radical neck dissection in laryngeal cancer. *Ann Otol Rhinol Laryngol* 1980;**89**: 578–81
11 Lingeman RE, Helmus C, Stephens R, Ulm J. Neck dissection: radical or conservative. *Ann Otol Rhinol Laryngol* 1977;**86**:737–44
12 Roy PH, Beahrs OH. Spinal accessory nerve in radical neck dissections. *Am J Surg* 1969;**118**:800–4
13 Schuller DE, Platz CE, Krause CJ. Spinal accessory lymph nodes: a prospective study of metastatic involvement. *Laryngoscope* 1978;**88**:439–50
14 Schuller DE, Saunders WH, Miglets AW, Kelly DR. Conservative neck dissection. Radical approach? *Arch Otolaryngol* 1981;**107**:642–5
15 Saunders JR Jr, Hirata RM, Jaques DA. Considering the spinal accessory nerve in head and neck surgery. *Am J Surg* 1985;**150**:491–4
16 Skolnik EM, Yee KF, Friedman M, Golden TA. The posterior triangle in radical neck surgery. *Arch Otolaryngol* 1976;**102**:1–4
17 Nahum AM, Mullally W, Marmor L. A syndrome resulting from radical neck dissection. *Arch Otolaryngol* 1961;**74**: 424–8
18 Williams PL, Dyson M, Bannister LH, Collins P, Berry MM, Ferguson MWJ *et al.*, eds. *Gray's Anatomy: the Anatomical Basis of Medicine and Surgery*, 38th edn. Edinburgh: Churchill Livingstone, 1999
19 McMinn RMH. *Last's Anatomy: Regional and Applied*, 9th edn. Edinburgh: Churchill Livingstone, 1994
20 Rhoton AL Jr, Buza R. Microsurgical anatomy of the jugular foramen. *J Neurosurg* 1975;**42**:541–50
21 Smith CG. *Basic Neuroanatomy*, 1st edn. Toronto: University of Toronto Press, 1971
22 Soo KC, Hamlyn PJ, Pegington J, Westbury G. Anatomy of the accessory nerve and its cervical contributions in the neck. *Head Neck Surg* 1986;**9**:111–15
23 Adetokunboh A, Ohata K, Tanaka K, Hakuba A. The microsurgical anatomy of the jugular foramen. *J Neurosurg* 1995;**83**:903–9
24 Levy D, Vacher C, Lezy JP. Relations of the accessory nerve with the internal jugular vein: surgical implications in cervical lymph node clearances. *Surg Radiol Anat* 2001;**23**:155–7
25 Gardiner KJ, Irvine BW, Murray A. Anomalous relationship of the spinal accessory nerve to the internal jugular vein. *Clin Anat* 2002;**15**:62–3
26 Prades JM, Timoshinko A, Dumollard JM, Durand M, Merzougui N, Martin C. High duplication of the internal jugular vein: clinical incidence in the adult and surgical consequences, a report of 3 clinical cases. *Surg Radiol Anat* 2002;**24**:129–32
27 Kierner AC, Zelenka I, Heller S, Burian M. Surgical anatomy of the spinal accessory nerve and the trapezius branches of the cervical plexus. *Arch Surg* 2000;**135**: 1428–31
28 Dailiana ZH, Mehdian H, Gilbert A. Surgical anatomy of spinal accessory nerve: is trapezius functional deficit inevitable after division of the nerve? *J Hand Surg* 2001; **26**:137–41
29 Hill JH, Olson NR. The surgical anatomy of the spinal accessory nerve and the internal branch of the superior laryngeal nerve. *Laryngoscope* 1979;**89**:1935–42
30 Caliot P, Bousquet V, Midy D, Cabanie P. A contribution to the study of the accessory nerve: surgical implications. *Surg Radiol Anat* 1989;**11**:11–15
31 Becker GD, Parell GJ. Technique of preserving the spinal accessory nerve during radical neck dissection. *Laryngoscope* 1979;**89**:827–31
32 Bater MC, Dufty J, Brennan PA. High division of the accessory nerve: a rare anatomical variation as a possible pitfall during neck dissection surgery. *J Craniomaxillofac Surg* 2005;**33**:340–1
33 Brown H, Burns SK, Kaiser CN. The spinal accessory nerve plexus, the trapezius muscle and shoulder stabilization after radical neck cancer surgery. *Ann Surg* 1988; **296**:654–61
34 Lu L, Haman SP, Ebraheim NA. Vulnerability of the spinal accessory nerve in the posterior triangle of the neck: a cadaveric study. *Orthopedics* 2002;**25**:71–4
35 Tubbs RS, Salter EG, Wellons JC 3rd, Blount JP, Oakes WJ. Superficial landmarks for the spinal accessory nerve within the posterior cervical triangle. *J Neurosurg Spine* 2005;**3**:375–8
36 Landau SI. *International Dictionary Of Medicine And Biology*. London: John Wiley, 1986;**3**
37 Hone SW, Ridha H, Rowley H, Timon CI. Surgical landmarks of the spinal accessory nerve in modified radical neck dissection. *Clin Otolaryngol Allied Sci* 2001; **26**:16–18
38 Kierner AC, Zelenka I, Burian M. How do the cervical plexus and the spinal accessory nerve contribute to the innervation of the trapezius muscle? As seen from within using Sihler's stain. *Arch Otolaryngol Head Neck Surg* 2001;**127**:1230–2
39 Hattori Y, Doi K, Toh S, Baliarsing AS. Surgical approach to the spinal accessory nerve for brachial plexus reconstruction. *J Hand Surg* 2001;**26**:1073–6
40 Al-Qattan MM, El-Shayeb A. Identification of the spinal accessory nerve within the surgical field during primary exploration of the brachial plexus in infants with obstetric palsy. *J Hand Surg* 2005;**30**:808–11
41 Kierner AC, Burian M, Bentzien S, Gstoettner W. Intraoperative electromyography for identification of the trapezius muscle innervation: clinical proof of a new anatomical concept. *Laryngoscope* 2002;**112**:1853–6
42 Weitz JW, Weitz SL, McElhinney AJ. A technique for preservation of spinal accessory nerve function in radical neck dissection. *Head Neck Surg* 1982;**5**:75–8
43 Stacy RJ, O'Leary ST, Hamlyn PJ. The innervation of the trapezius muscle: a cervical motor supply. *J Craniomaxillofac Surg* 1995;**23**:250–1
44 Soo KC, Guiloff RJ, Oh A, Della Rovere GQ, Westbury G. Innervation of the trapezius muscle: a study in patients undergoing neck dissections. *Head Neck* 1990;**12**:488–95
45 Eisele DW, Weymuller EA Jr, Price JC. Spinal accessory nerve preservation during neck dissection. *Laryngoscope* 1991;**101**:433–5
46 Pereira MT, Williams WW. The spinal accessory nerve distal to the posterior triangle. *J Hand Surg* 1999;**24**:368–9

https://doi.org/10.1017/S0022215107000461 Published online by Cambridge University Press

47 Jobe CM, Kropp WE, Wood VE. Spinal accessory nerve in a trapezius-splitting surgical approach. *J Shoulder Elbow Surg* 1996;**5**:206–8
48 Bertelli JA, Ghizoni MF. Improved technique for harvesting the accessory nerve for transfer in brachial plexus injuries. *Neurosurgery* 2006;**58**(suppl 2):366–70
49 Leung MK, Dieu T, Cleland H. Surgical approach to the accessory nerve in the posterior triangle of the neck. *Plast Reconstr Surg* 2004;**113**:2067–70
50 Baring DE, Johnston A, O'Reilly BF. The identification of the accessory nerve by its relationship to the great auricular nerve. *J Laryngol Otol* 2007 (In press)
51 King RJ, Mott AG. Iatrogenic accessory nerve palsy. *Ann R Coll Surg Engl* 1983;**65**:35
52 Salasche SJ, Bernstein G, Senkarik M. *Surgical Anatomy of the Skin*. Norwalk, Connecticutt: Appleton and Lange, 1988;12, 116–17, 263–5
53 Rafferty MA, Goldstein DP, Brown DH, Irish JC. The sternomastoid branch of the occipital artery: a surgical landmark for the spinal accessory nerve in selective neck dissections. *Otolaryngol Head Neck Surg* 2005;**133**:874–6
54 Tatla T, Kanagalingam J, Majithia A, Clarke PM. Upper neck spinal accessory nerve identification during neck dissection. *J Laryngol Otol* 2005;**119**:906–8
55 Chaukar DA, Pai A, D'Cruz AK. A technique to identify and preserve the spinal accessory nerve during neck dissection. *J Laryngol Otol* 2006;**120**:494–6
56 Deschler DG, Singer MI. Preservation of spinal accessory nerve in modified neck dissections. *Laryngoscope* 1996; **106**:664–6
57 Stearns MP, Shaheen OH. Preservation of the accessory nerve in block dissection of the neck. *J Laryngol Otol* 1981;**95**:1141–8
58 Fisher DA. A simple method of identifying the spinal accessory nerve. *Dermatol Surg* 2000;**26**:384–6
59 Midwinter K, Willatt D. Accessory nerve monitoring and stimulation during neck surgery. *J Laryngol Otol* 2002; **116**:272–4

Address for correspondence:
Mr S K Lloyd,
C/o Mr G Kenyon,
Whipps Cross University Hospital,
London E11 1NR, UK.

Fax: 020 7431 8897
E-mail: SKLloyd@blueyonder.co.uk

Mr S K Lloyd takes responsibility for the integrity of the content of the paper.
Competing interests: None declared

https://doi.org/10.1017/S0022215107000461 Published online by Cambridge University Press