

The spinal accessory nerve in head and neck surgery

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Purpose of review

To describe landmarks and tips used for minimizing surgical traumas to the spinal accessory nerve, and different options in case of its injury.

Recent findings

Modified radical and selective neck dissections reduce the prevalence of shoulder syndrome, a sequela of radical neck dissection. Impaired shoulder mobility and pain may be present even after nerve-sparing procedures, as shown using electromyography, particularly when dissection is extended to level V. In these cases physical therapy is mandatory to prevent shoulder pain and functional limitations. The issue of spinal accessory nerve repair when macroscopically damaged or transected remains critical.

Summary

Subclinical spinal accessory nerve impairment can be observed even after selective neck dissections (levels II–IV) due to routine clearance of sublevel IIB. Further studies should be performed to select patients in whom this sublevel could be left undissected without impairing oncologic radicality and to demonstrate if such a policy leads to better functional results. Early diagnosis of shoulder syndrome by questionnaires and clinical tests is recommended to appropriately plan physical therapy. Spinal accessory nerve repair is advocated to reduce the prevalence of shoulder syndrome after radical neck dissection. More data are needed to assess the superiority of newer techniques such as nerve transposition or bioresorbable nerve guides.

Keywords

shoulder function, shoulder syndrome, spinal accessory nerve

Abbreviations

EMG	electromyography
ERND	extended radical neck dissection
MRND	modified radical neck dissection
RND	radical neck dissection
SAN	spinal accessory nerve
SND	selective neck dissection
SS	shoulder syndrome

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Introduction

The gold standard for treatment of head and neck cancer is based on appropriate planning of surgical, radiotherapeutic and medical strategies aimed to treat both the primary lesion and the neck, and, at the same time, on the attempt to minimize permanent sequelae with a negative impact on the quality of life. In this respect, one of the most debated issues is the reduction of morbidity related to the sacrifice or temporary lesion of the spinal accessory nerve (SAN) during neck dissection.

A large spectrum of surgical procedures is presently available for treatment of cervical lymph nodes. According to the nomenclature suggested by the American Head and Neck Society and the American Academy of Otolaryngology–Head and Neck Surgery, these can be classified as radical neck dissection (RND), extended RND (ERND), modified RND (MRND) and selective neck dissection (SND) [1]. When appropriately planned, even more conservative procedures such as MRND and SND comply with the principles of oncologic radicality; furthermore, they have the additional advantage of minimizing functional disabilities resulting from RND and ERND.

A number of reports have reviewed the functional sequelae after RND [2–5]. The most relevant functional aspect is undoubtedly the impairment of shoulder function due to sectioning the SAN and to the ensuing denervation of the upper trapezius muscle. Nahum *et al.* [6] coined the term ‘shoulder syndrome’ (SS) to describe a clinical picture consisting of pain and limited abduction of the shoulder, full passive range of motion, and anatomic deformities such as scapular flaring, droop and protraction. Pain is attributed to strain placed on other supporting muscles, such as the rhomboids and levator scapulae, as a consequence of shoulder drooping. A frequent ancillary sign of SS is sternoclavicular joint hypertrophy, due to the abnormal torque-like forces applied to the medial head of

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the clavicle, potentially complicated by stress fracture of the middle third of the clavicle [7].

Management of the spinal accessory nerve after radical neck dissection

The SAN is usually described as a purely motor nerve providing innervation to the sternocleidomastoid and upper trapezius muscles. After loss of nerve function, paralysis of both muscles occurs and the loss sternocleidomastoid activity is generally of secondary importance with respect to upper trapezius denervation, which causes the complex clinical picture of SS. Severe upper extremity impairment with either functional motor deficits, stiffness of the neck and shoulder pain that may radiate to the face have been found in up to 60–80% of patients treated by RND [3,6].

Following the report of Harris and Dickey [8], who first described a cable grafting technique to restore SAN function, other authors have clearly demonstrated the improvement of shoulder function in the postoperative period using immediate reconstruction of the nerve by a microsurgical technique and a cable graft of the great auricular nerve [9]. Other techniques can include using the sural or anterior branch of the medial antebrachial cutaneous or thoracodorsal as interposition nerves. A major concern of these techniques is the increased morbidity: some patients do not benefit from this procedure due to neuroma formation and ingrowth of fibrous tissue blocking the axon sprouting from the proximal nerve, particularly when a long and nonvascularized cable graft is required and a postoperative course of radiotherapy is needed. An alternative method to restore SAN conduction is by using the technique described by Guo *et al.* [10], which utilizes the proximal portion of the sternocleidomastoid and the great auricular nerve as a flap, with the advantage of having an interposition nerve graft vascularized by the fascia and muscle, with no donor site morbidity. A key aspect is to leave the SAN intact in the posterior triangle of the neck, whenever oncologically feasible. A large series of patients, however, still needs to be evaluated in order to assess the actual advantages of this method in restoring postoperative function after RND.

Management of the spinal accessory nerve after modified radical neck dissection or selective neck dissection

Theoretically, neck dissections sparing the SAN should result in absent or only slight shoulder dysfunction and pain when compared with RND; however, this is not always the case. The reported prevalence of SAN transection after MRND or SND greatly differs according to the diagnostic technique applied; from a purely clinical stand point, SS has been diagnosed as an unexpected complication due to SAN division in 1.68% of MRNDs

from a large retrospective European series [11]. Moreover, it is well documented that some patients with severe injury to the SAN do not experience the degree of dysfunction that one would expect from their evaluation by electromyography (EMG). In contrast, patients treated with nerve-sparing procedures may present evident signs of muscle dysfunction. These apparently contradictory results can be explained by the influence of several factors including age, gender, right or left handedness, presence of concurrent neuropathy or myopathy, condition of other synergistic shoulder girdle muscles and pre- or postoperative radiotherapy [3,12].

Furthermore, there is still considerable debate regarding upper trapezius muscle innervation. Some authors consider the SAN as the only motor supply [13,14], while others maintain that this nerve and the cervical plexus branches provide a variable contribution to upper trapezius motor innervation [15–17]. Recent anatomical studies by Kierner *et al.* [18–20] have clarified the relationship between the SAN and the cervical plexus. According to their observations, only a single fine branch of the SAN runs to the upper trapezius without any contribution from the cervical plexus. No anastomosis was demonstrated between this branch and the nerve passing into the muscle more caudally or in connection with the communicating branches at Erb's point, except in cases in which the SAN does not run through the sternocleidomastoid but dorsal to it (one-third of patients). Finally, one to three (in most cases two) branches of the cervical plexus run to the middle and lower trapezius; they are always subfascial and run in the posterior triangle of the neck independently of the SAN, and only rarely intermingle with it.

Since the first observation of the presence of shoulder impairment even in nerve-sparing neck dissections made by Leipzig *et al.* [3], who reported permanent shoulder droop in 25% of patients, other authors evidenced this complication in 5% of cases in which levels II–IV were cleared and in 30% of cases with dissection of level V [21]. In this latter group, one patient, the same that had EMG findings of total denervation of the upper trapezius with minor impairment of the sternocleidomastoid, showed all the classic static alterations of SS. This can be explained by traction, skeletonization and devascularization of the SAN, believed to be responsible for its segmental demyelination and consequent neuroapraxia, during clearance of the posterior triangle of the neck, inadvertent transection of the nerve or, more frequently, of its fine branch directed to the upper trapezius, in the posterior triangle of the neck [20].

Zibordi *et al.* [22] first tested the sternocleidomastoid after SND by EMG, observing that patients with neurogenic peripheral lesions of this muscle outnumbered

those with upper trapezius damage. They believed that the difference was due to the small size of the SAN branch innervating the sternocleidomastoid and to the more severe surgical trauma. This assertion corresponds to our experience, but only in patients in which the dissection is limited to the submuscular recess (sublevel IIB) and the lateral neck (levels IIA–IV). In our series [21], EMG abnormalities were more evident in the upper trapezius than in the sternocleidomastoid in those patients who underwent clearance of level V, even though no statistical difference between the two groups was observed when comparing the nerve conduction tests.

Management of the spinal accessory nerve after accidental transection

Immediate surgical repair is advocated in the case of accidental transection of the nerve, generally with the interposition of a cable nerve graft (usually the ipsilateral great auricular nerve), considering the unsuitability of direct nerve suture due to excessive tension of the nerve stumps. Based on the experience of Den Dunnen *et al.* [23,24], we recommend the use of bioresorbable nerve guides, which have the following advantages over autologous nerve grafts: fast and simple procedure, no need for a second surgical procedure to harvest donor nerve tissue, no donor site morbidity, unlimited off-the-shelf availability of diameters and lengths of nerve guides, which are transparent and facilitate optimal positioning of the nerve stumps into the tube, and improved nerve function recovery with less adverse side effects. The nerve gap recovery is up to 3 cm with prevention of neuroma formation and ingrowth of fibrous tissue that blocks the axon sprouting from the proximal stump.

Spinal accessory nerve function and sublevel IIB

A large number of recent reports have attempted to define the oncologic safety of further reducing SND (II–IV), avoiding dissection of sublevel IIB in selected patients [25–28]. Even though for some sites (larynx, oropharynx and hypopharynx) and in the case of cN0 patients this can be considered a reasonably sound procedure, there is no clear demonstration of functional gain in terms of shoulder morbidity.

Some authors have shown temporary functional deterioration of the SAN even when sublevel IIB is not dissected [29**]. In particular, they found no statistically significant differences between sublevel IIB-dissected and sublevel IIB-undissected patients in terms of spontaneous electrical discharge at EMG and motor unit potentials during the late postoperative period. It was concluded that these two groups of patients presented similar axonal deterioration without EMG evidence of better SAN functional results in the sublevel

IIB-undissected group. These data need to be confirmed by other studies, with a larger cohort of patients and longer follow-up.

To reduce surgical trauma to the SAN in sublevel IIB, some anatomical landmarks can be used, such as the sternomastoid branch of the occipital artery, which is the superior vascular pedicle of the sternocleidomastoid. Anatomical data have clearly demonstrated the utility of this landmark, which crosses the SAN at a mean distance of 6.2 mm (range 1–11 mm) below the point where the nerve enters the muscle, at a slightly deeper level than the perforator itself, thus reducing nerve trauma if sharp dissection and no cautery are used [30]. Finally, particular care must be taken to mobilize the nerve when sublevel IIB is dissected, avoiding excessive strength with retractors, or better using a cottonoid or vessel loops.

Diagnostic tests for evaluation of shoulder syndrome

Electrodiagnostic tests are the most sensitive for detection of nerve conduction impairment, generally evident in any type of neck dissection, and their use is indicated in monitoring upper trapezius recovery of function during follow-up, to be generally prolonged for at least 1 year after neck dissection. In most patients electrophysiologic alterations are not clinically associated with pain or limitations during daily activities or with either static or dynamic shoulder impairment. Range of motion tests, particularly shoulder abduction with a contralateral head rotation strength test, which reduces the number of upper trapezius fibers reaching the cervical spine to allow head rotation, have shown a positive correlation with EMG findings [21]. In this light, this maneuver can be considered a reliable and cost-effective tool for evaluating the degree of upper trapezius denervation.

SS should not be underestimated even when the SAN has been anatomically preserved during surgery, in order to adequately plan a physical therapy course and reduce postoperative morbidity. For this reason, it is important to recognize the functional status of the shoulder as early as possible by clinical evaluation using an adequate questionnaire that may reflect the impact of any neck dissection on postoperative dysfunction. In recent years, there has been a growing interest in the development of head and neck disease-specific quality of life questionnaires, some of which have focused on shoulder function after neck dissection. These subjective tools have also been demonstrated to be effective for shoulder evaluation in patients undergoing SND [12,31–35].

Physical therapy for shoulder syndrome

Postoperative impairment of the upper trapezius should be managed by an appropriate physical therapy program, including exercises that patients can perform by

themselves at home, contributing to maintaining a sufficient range of motion of the shoulder joint, before fibrosis occurs causing secondary glenohumeral adhesion, scapulohumeral girdle muscles weakness and postoperative forced immobility. Evidence has been presented that such a postoperative treatment policy aids in reducing adverse shoulder symptoms after any type of neck dissection [36]. The rationale is to prevent any restriction of passive mobility caused by stiffness of capsular and ligaments during the first postoperative months to allow more rapid recovery of active motility once the upper trapezius completely recovers its dynamic properties. In particular, Salerno *et al.* [37] stress the importance of early (within 15–30 days after surgery) and prolonged (1–6 months) rehabilitation including passive forward elevation of the arm in the plane of the scapula in supine and half-sitting positions, passive forward elevation with the hands locked in supine and half-sitting positions and subsequent stretching movements, external rotation with the elbow at the side and flexed at 90°, and internal rotation with the hand placed behind the back. In so doing, important gains were seen by measuring global passive and active shoulder mobility, quality of life in terms of pain and return to previous occupational and recreational activities, and quantitative EMG of the upper trapezius, supraspinatus, infraspinatus and levator scapulae muscles.

A supportive tool after RND is represented by the use of the Akman–Sari shoulder orthosis, which consists of a rectangular piece of polyethylene, to be placed by the patient in the axillary region of the affected side covering the inferior angle and the lateral edge of the scapula, coupled with a nonelastic band passed over the contralateral shoulder and under the contralateral axilla [38]. This orthosis stabilizes the affected shoulder girdle and aligns it with the healthy one to obtain reduction of stretch and torsion applied on the scapulohumeral joint, with consequent pain relief. While the active abduction range of the upper limb is only moderately improved (with a reported gain ranging from 5° to 20°), the quality of life questionnaire showed that 72% of patients were completely pain-free within 3 months after RND and 82% were able to return to previous job or activity levels. Even though the authors claim this orthosis to be practical, easy to wear or take off and cosmetically acceptable, 12% of patients discontinued its use before the end of the prospective study.

Conclusion

Our data confirm that surgical manipulation of the SAN even during SND may produce impairment of nerve conduction, particularly when its dissection is carried along the posterior triangle of the neck (level V). Subclinical and/or nearly asymptomatic nerve impairment can be observed even after SND from levels II–IV if

the submuscular recess (sublevel IIB) is routinely dissected. Further studies are needed to carefully select patients in whom such a level could be left undissected without impairing oncologic radicality and to demonstrate if this precaution leads to better functional results. Early diagnosis with questionnaires and clinical tests is recommended to appropriately plan physical therapy of SS.

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