

Neck dissection: past, present and future?

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Abstract

With the exception of distant metastasis, the presence of cervical lymph node metastasis is the single most adverse independent prognostic factor in head and neck squamous cell carcinoma. Surgical removal of metastatic cervical lymph nodes had been attempted during the late nineteenth century, with varying techniques and poor results. A systematic approach to en bloc removal of cervical lymph node disease, described in detail by Jawdyński at the end of the nineteenth century and popularized and illustrated by Crile in the early twentieth century, provided consistent and more effective treatment and forms the basis of our current techniques. The concepts of radical neck dissection, employed extensively by Martin, were followed with almost religious consistency by most head and neck surgeons until the late twentieth century, when the principles of 'functional' neck dissection, developed by Suárez and popularized by Bocca, Gavilán, Ballantyne, Byers and others, led to the acceptance of modified radical neck dissection as treatment for lymph node disease in various stages. More recently, selective neck dissection, involving removal of nodes confined to the levels at greatest risk of metastasis from primary tumours at various sites, has become accepted practice for elective and, in some instances, therapeutic treatment of the neck. In the future, sentinel lymph node biopsy and the use of molecular pathological analyses may be employed to predict the presence of occult cervical disease, thus directing therapy to patients at greatest risk and sparing those without regional metastasis.

Key words: Neck Dissection; Radical Neck Dissection; Functional Neck Dissection; Selective Neck Dissection

Introduction

Management of metastasis to the cervical lymph nodes is of paramount importance in treatment of patients with tumours of the head and neck. The majority of squamous cell carcinomas of the head and neck metastasize to the cervical lymph nodes at some point in the course of disease.¹ With the exception of distant metastasis, the presence of cervical lymph node metastasis is the single most adverse independent prognostic factor in head and neck squamous cell carcinoma.²

Neck dissection in its various forms is the standard procedure for surgical treatment of clinical, sub-clinical and sub-pathological cervical lymph node metastasis. Opinions vary, however, as to the indications for neck dissection and the type of dissection for different situations.¹

Historical perspective

The surgeons of the nineteenth century were aware that cancers of the head and neck metastasize to

the cervical lymph nodes. They often regarded the finding of metastatic lymphadenopathy as an indication of incurability, but occasionally they would include the resection of grossly involved lymph nodes with the excision of the primary cancers. These incomplete resections of lymph node metastases were usually ineffective, thus justifying the dismal prognosis.³ However, it was realized that cervical lymph node metastases, if present, must be removed with the primary cancer if the patient was to be given any chance of survival.

In 1837, Warren⁴ reported an attempt at removal of cancer in the neck using an improvised technique. In 1880, Kocher⁵ recommended that involved lymph nodes be removed with ample resection margins and introduced the so-called 'Kocher' incision (a Y-shaped incision) for this purpose, with the long arm extending from the mastoid to the level of the omohyoid muscle at its junction with the anterior border of the sternocleidomastoid muscle. Kocher⁵ advocated lymph node dissection of the

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submandibular triangle while performing a transcervical approach for the surgical removal of tongue cancer. In 1881, JH Packard (as quoted by Martin *et al.*)⁶ supported the recommendation that the submandibular and sublingual glands be removed in lingual cancer. In 1882, Volkmann⁷ reported two cases of radical en bloc neck dissection in his paper 'Das tiefe branchiogene Halskarzinom'. B Langenbeck (quoted in Towpik)⁸ was also cited as performing two radical resections involving the jugular vein and carotid artery. Both patients died soon after surgery. In 1885, however, Butlin⁹ questioned the advisability of performing radical neck dissection for mouth cancer that clinically had not invaded the cervical lymph nodes.

In 1888, Jawdyński,¹⁰ a Polish surgeon, performed a surgical intervention similar to the technique described 17 years later by Crile,¹¹ which was called radical neck dissection. The paper, published in a Polish journal, remained virtually unknown abroad. Jawdyński performed the operation on 17 January 1888 and described it in great detail:

I made the incision from the mandibular angle to the sternoclavicular joint ... at the front the tumour was resected together with the sternocleido-mastoid muscle ... at the bottom we dissected and cut the internal jugular vein after placing double ligatures on both sides ... moving upwards, we left the vagus nerve intact and finally ligated and cut the vein at the upper end Unfortunately, the carotid artery was infiltrated, especially at the level of bifurcation, to such extent, that it could not be saved ... therefore it was ligated and cut below the tumour Subsequently, external and internal carotid arteries were ligated and cut above the tumour ... the external artery was divided above the superior thyroid branch The cavity left after removal of the specimen was surrounded by the vagus nerve and vertebral column from behind, by the lateral wall of the pharynx, larynx and hyoid bone and respective muscles from the midline, by the ligated stumps of big vessels from the bottom, and by the digastric muscle, sublingual gland, hypoglossal nerve, lingual artery and the stumps of ligated vessels from above.^{8,10}

In 1990, Towpik,⁸ a Warsaw physician, published in an international journal a note regarding the centennial of the first description of en bloc neck dissection, putting some facts and dates in a proper perspective. In particular, he pointed out that the first detailed description of en bloc neck dissection was reported in Polish by Jawdyński in 1888.¹⁰ Towpik concluded his note by quoting W Osler: 'in science the credit goes to the man who convinces the world, not to the man to whom the idea first occurs'.⁸

In 1901, Solis-Cohen¹² mentioned the necessity of removing the neck lymphatics during total laryngectomy, regardless of whether or not they showed any clinical evidence of cancer.

In 1905, George Washington Crile¹¹ of Cleveland, Ohio, published a systematic approach to neck dissection in the *Transactions of the Southern Surgical and Gynecological Association*. The paper was based on the results of 121 operations performed upon 105 patients. This paper was accompanied by 12 very clear drawings. Crile's paper was followed by an interesting discussion, nine pages in length, that raised issues such as the use of less radical surgery for early cancers and for primary tumours at specific sites. Although rarely cited because of its obscure publication, his landmark paper established the basis for effective treatment of such lesions by describing a block resection of the cervical lymph node-bearing tissue, to be removed either in continuity with the primary tumour or as a secondary operation for subsequent metastasis.

The paper was based on the personal experience of the author, who had been performing this surgical procedure since 1900. The 'Crile operation' has remained one of the more frequently used eponyms in oncology.⁸ En bloc dissection was intended to control metastatic lymph nodes by completely resecting involved lymph nodes between the superficial and deep cervical fascia, together with neck structures in close proximity from the base of the skull to the level of the clavicle.

In 1906, Crile¹³ published a second paper on block neck dissection, this time in the *Journal of the American Medical Association*, reporting the results of 132 operations, accompanied by the same illustrations that had appeared in the previous publication. The paper was also followed by an interesting discussion. Almost all contributors mentioned Crile's second paper¹³ as being the first description of a systematic en bloc removal of the neck lymphatics, as they were unaware of his earlier publication.¹⁴⁻¹⁶ Thus, Crile raised radical neck dissection for head and neck cancer to a level equivalent to that of the Halsted procedure for the treatment of breast cancer.

Since the time of Crile, much has been done to modify, standardize and establish indications for neck dissections for head and neck cancer. Several surgical schools have favoured a more conservative operation. In 1926, Bartlett and Callander¹⁷ described neck dissections with preservation of the spinal accessory nerve, the internal jugular vein, the sternocleidomastoid muscle, the platysma muscle, the stylohyoid muscle and the digastric muscle. Conversely, in 1933, Blair and Brown¹⁸ advocated removal of the spinal accessory nerve during neck dissection because resection of the nerve allowed more total removal of the cervical lymph nodes and decreased operating time.

By 1944, Sylvestre-Benis¹⁹ had established the place of radical neck dissection in the treatment of laryngeal cancer. He recognized the possibility of 'monoblock' extirpation of the primary lesion in the larynx together with its lymphatic shed and thus advocated simultaneous unilateral or bilateral neck dissection with total laryngectomy in patients with palpable nodes. Sylvestre-Benis performed 'limited' neck dissections in cases in which he felt the disease was confined to the jugular nodes.

The greatest impetus for the development of radical surgery for the treatment of head and neck cancer came from Martin *et al.*,⁶ who compiled extensive experience in the treatment of head and neck cancer by both radiation and surgery, from the 1920s to the 1950s. In 1951, Martin and his colleagues published an analysis of 1450 cases of neck dissection. This classic paper was most influential in defining the technique and gaining acceptance for radical neck dissection. The technical precepts described by Martin *et al.* were followed with almost religious consistency by many US surgeons for many years. In the latter part of the last century, a number of modifications in technique became accepted. Martin *et al.* advocated complete, rather than partial, neck dissection but did not favour 'prophylactic' or elective neck dissection, except in cases in which they felt that dissection of the neck was truly an integral part of the resection itself.³ Martin *et al.* refined Crile's original operation and popularized it in the USA in its currently used format. They categorically stated that 'Any technique that is designed to preserve the spinal accessory nerve should be condemned unequivocally'. Although this surgical option was effective and considered the 'gold standard', it also caused significant aesthetic and functional morbidity. Conley,²⁰ another strong proponent of radical neck dissection, stated that 'radical neck dissection is the key to control of metastatic cancer in the neck'.

To prevent the significant long term morbidity of radical neck dissection, including shoulder dysfunction, cosmetic deformity, cutaneous paraesthesia, and chronic neck and shoulder pain syndrome, Suárez²¹ developed in 1952 a 'functional' neck dissection. Although often forgotten in the English language literature, Suárez is truly the 'father' of functional neck dissection.²²

In his 1963 publication, Suárez²¹ stated that:

All of these techniques have been correctly described and, having practised them numerous times, we were able to note that in some cases removal was not enough, whereas in others the patient had undergone unnecessary mutilation, which carried an unjustified risk of lesions and complications. With the so-called radical dissection, in particular, – despite its charming name – recurrent lymph nodes can be seen in the immediate or late postoperative period.

Taking all these reasons into account, and having seen the drawbacks of severe facial edema determined by the ligation of the two jugular veins, the increasing frequency of fistulas, skin necrosis, and, especially, terrible rupture of the carotid artery with severe, generally irreparable consequences, since 1952 we have used a technique that enables us to completely eliminate the lymph node tissue in the neck along with the primary tumour, while carefully preserving the noble structures such as the sternocleidomastoid (SCM) muscle, the omohyoid muscle, the submandibular gland,

the internal jugular vein, and sometimes the spinal accessory nerve. Particularly, [it is] the SCM muscle with its spinal accessory nerve, that enables protection of the carotid artery and prevention of its rupture, as well as ensuring the absence of subcutaneous carotid bulbs beating under the skin, that originate a series of painful phenomena, causing not only an aesthetic problem but also discomfort to the patient.

Functional neck dissection preserves important structures, such as the sternocleidomastoid muscle, the internal jugular vein and the spinal accessory nerve. Later, Bocca, alone and with colleagues,^{23–28} and Gavilán with colleagues,^{29–31} popularized this less aggressive but equally effective surgical method for treatment of appropriately staged cancers.³²

There has been a persistent lack of uniformity in classification of various neck dissections. The term 'functional neck dissection' has been abandoned and replaced by 'modified radical neck dissection'. The various types of modified radical neck dissection have in common the removal of lymph node groups I to V with preservation of at least one of the non-lymphatic structures sacrificed in radical neck dissection.^{33–35}

During the 1960s, surgeons at the MD Anderson Hospital began to selectively remove only the lymph node groups of the neck that were at highest risk of containing metastases, based on the location of the primary tumour.³⁶ Interestingly, most of the studies that establish a pathological justification for this approach were published many years later. In particular, MD Anderson Hospital surgeons Richard Jesse, Alando Ballantyne and Robert Byers perfected the technique of modified neck dissection and popularized it in the USA. These surgeons also studied extensively the role of elective versus therapeutic neck dissection in the USA and convinced the community of oncologic surgeons that modified neck dissection did adhere to oncologic principles. However, the most common modified neck dissection performed by this group was either a supraomohyoid neck dissection or a jugular neck dissection (referred to as an 'anterior neck dissection').³²

Present perspective

In response to the increasing types of neck dissections performed in practice and to the variations in technique and, in particular, in terminology, the Committee for Head and Neck Surgery and Oncology of the American Academy of Otolaryngology–Head and Neck Surgery, chaired by Robbins, standardized neck dissection terminology in 1991.³⁵ A subsequent update was published in 2002.³⁷ The categories for classifying neck dissection thus established were: radical neck dissection, modified radical neck dissection, selective neck dissection and extended neck dissection.³⁷ This recently updated classification thus represents a consensus among members of the two major organizations of American head and neck

surgeons. It does not differ substantially from the recommendations of the Academy's Committee on Neck Dissection, published a decade earlier. The two most significant changes concern the way in which various selective neck dissections are described (each variant is depicted by 'SND' and the use of brackets to denote the levels or sub-levels removed) and the use of radiologically depicted anatomical structures to define boundaries between various neck levels and sub-levels to ensure an accurate designation of the imaged nodes.³⁸ The committee opted to divide some neck levels into sub-levels, separating level I into sub-levels IA (submental lymph nodes) and IB (submandibular lymph nodes), level II into sub-levels IIA (subdigastric lymph nodes) and IIB (supraretrospinal or submuscular recess), and level V into sub-levels VA (spinal accessory nodes) and VB (transverse cervical and supraclavicular nodes).^{39–42} For modified radical neck dissection, the structure(s) preserved should be specifically named (e.g. modified radical neck dissection with preservation of the spinal accessory nerve).³⁷

Selective neck dissections and the earlier described functional neck dissection have many similarities. Both are most often used electively or for selected patients with a clinically positive neck.⁴³ There is also a role for selective neck dissection after chemoradiation for head and neck cancer.^{44,45} Several authors have been looking at ways to perform super-selective neck dissections^{46,47} in light of the pattern of metastases of the cancers of the head and neck.⁴⁸ These surgical procedures appear to be oncologically safe and to decrease the morbidity of surgery.

Future perspective

At the time of writing, the Committee for Head and Neck Surgery and Oncology of the American Academy of Otolaryngology–Head and Neck Surgery has been working on a revised classification for neck dissection with the aim of keeping classification contemporary.

In the future, sentinel lymph node biopsy of cervical lymph nodes may play a useful role in the management of patients with head and neck cancer.⁴⁹ Sentinel lymph node biopsy is based on the principle that lymph node metastases do not occur in a random manner, but rather occur predictably, in accordance with pre-existing lymphatic anatomy.⁵⁰ Currently, sentinel lymph node biopsy should not be considered a proven diagnostic tool and should be performed only within the context of clinical trials. It has not yet achieved the status of 'standard care' for the treatment of head and neck cancer patients.⁴⁹ Further research is needed.^{51–54}

Recently, there has been considerable progress in molecular approaches to the evaluation of head and neck cancer. However, despite the great promise of these new molecular applications for cancer detection, much of the current technology limits their implementation in routine clinical use.⁵⁵ In particular, several molecular investigations show no correlations between the various markers investigated and the presence of pathologically positive lymph

nodes, at least no correlations strong enough to be useful in clinical practice.^{56,57} However, in 2005, Ferris *et al.*,⁵⁸ using quantitative reverse transcription-polymerase chain reaction (QRT-PCR), identified four markers that discriminated between positive and benign nodes with an accuracy greater than 97 per cent. These markers were pemphigus vulgaris antigen (PVA; also known as desmoglein-3), squamous cell carcinoma antigen (SCCA1/2; neutral and acidic forms), parathyroid hormone-related protein (PTHrP) and tumour-associated calcium signal transducer (TACSTD1; also known as epithelial cell adhesion molecule (EPCAM)). Moreover, one of these markers, PVA, discriminated with 100 per cent accuracy between positive and benign lymph nodes. Thus, it seems that single-marker QRT-PCR analysis for PVA could be adequate for staging of cervical lymph nodes in head and neck squamous cell carcinoma. The authors have developed a rapid QRT-PCR assay for PVA, incorporated into a completely automated ribonucleic acid (RNA) isolation and QRT-PCR instrument (the GeneXpert) (<http://www.warmwell.com/genexpert.html>) developed for molecular diagnostic testing. The automated PVA analysis also provided perfect discrimination between benign and malignant lymph nodes, and was completed (from tissue to result) in about 30 minutes, thus demonstrating the feasibility of intra-operative staging of head and neck squamous cell carcinoma sentinel lymph nodes by QRT-PCR.

On the other hand, it has been demonstrated that metastases show similar profiles to the primary tumours that they arose from, suggesting that the biological properties of a primary tumour can reflect the properties of its metastases.⁵⁹ To take this one step farther, it has been shown that the presence of metastasis can be predicted based upon gene expression patterns present in the primary tumour.^{60,61} In these studies, using c-deoxyribonucleic acid (cDNA) microarrays, the authors identified gene expression patterns capable of predicting the presence of lymph node metastases with an overall accuracy as high as 86 per cent – that is, substantially better than current clinical diagnosis. Furthermore, in the work of Roepman *et al.*,⁶¹ the predictor (composed of a set of 102 genes) had a predictive accuracy for N₀ status of 100 per cent. At the time of study, no false negative predictions were made, which is most important for the goal of achieving clinical relevance. These studies suggest that the metastatic state can be deciphered from the primary tumour gene-expression pattern.⁵⁵

Molecular pathologic analysis will determine the biologic impact of these new and stimulating observations as we continue to increase our understanding of metastases and their management.²

Although the overall survival of patients with head and neck cancer has remained largely unchanged since the early 1970s, the morbidity from its treatment has lessened significantly. Surgery still plays the major role in treating cervical metastatic disease. Modifications in the type of neck dissection

have been the main factors responsible for the reduction in morbidity from these procedures.⁶²

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