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Review Article

Minimizing complications in neck dissection

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'An ounce of prevention is worth a pound of cure . . .'

Introduction

The ultimate complication in neck dissection is residual or recurrent tumour. Good technique allows for both maximal eradication of disease and for better outcome with improved survival.

The goal of this discussion is to present, in light of the literature, a planned approach for the patient undergoing neck dissection beginning with the pre-operative evaluation and ending at the patient's discharge from the hospital. Peri-operative complications increase morbidity and delay wound healing. This may delay or overall void the option for post-operative radiation treatment, thus further reducing survival.

Also, on top of severe patient discomfort and suffering, pain and frustration, increased costs of prolonged hospital stay, intensive care, expensive antibiotic treatment and the need for repeated surgical procedures are also an important consideration in trying to minimize complications. Much of what will be discussed is applicable to most procedures in the head and neck but many details are specific for radical or modified neck dissections.

General considerations

Consideration of diabetes mellitus, renal dysfunction, immunosuppression, obesity, hepatic failure, and pulmonary, cardiac and adrenal insufficiency are beyond the scope of this discussion. These conditions may predispose to increased local wound and systemic complications and the surgeon must not only be aware of their presence, but be familiar with peri-operative necessary changes and adaptations in treatment regimen and specialized monitoring and care.

Peri-operative antibiotics and infection

The value of systemic peri-operative antibiotics in clean-contaminated head and neck surgery is probably indisputable (Carrau *et al.*, 1991; Weber, 1997).

Aseptic technique with povidone iodine irrigation of the wound before closure may suffice in smaller procedures, and yet, many head and neck surgeons administer prophylactic antibiotic treatment in some form or other. Although isolated neck dissection is not a lengthy procedure, comprehensive procedures require prolonged exposure of the wound and with the need to alter the patient's head position and dampening of drapes with blood and irrigation fluids, the sterility of the field may be violated. Also, withholding prophylactic treatment does not reduce costs in analysis of post-operative wound infection (Blair *et al.*, 1995).

Comparison of three prophylactic antibiotic regimens in clean-contaminated procedures showed a comparable effect of amoxycillin-clavulanate, clindamycin plus gentamicin and cefazolin (Rodrigo *et al.*, 1997). Non-wound infection was reported to occur in 10 per cent of patients receiving prophylactic treatment. Most infections were pulmonary in origin and prolonged surgery, heavy smoking, blood transfusion and hypoalbuminaemia were all found to be significant risk factors.

Antibiotics should be selected against likely pathogens, single agent prophylaxis may be effective, the half-life of drug should be considered and repeated if the procedure lasts longer than twice the half-life, but is usually not warranted beyond 24 hours. A single pre-operative dose may suffice in a short procedure or where no significant blood loss occurred.

Good surgical technique with minimal tissue damage, judicious use of cautery, proper approximation of tissues to prevent dead space formation but also necrosis due to over-tightening are important in

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preventing infection. Minimal skin tension is advisable at closure to prevent dermal stretching with subsequent compromise of blood flow. Haemostasis is also important in preventing haematoma formation and infection.

Hypothyroidism

Hypothyroidism is a well-recognized complication of single treatment modality and combined treatment for cancer of the head and neck. This entity is usually of insidious onset and occurs in 29–66 per cent of cases. A high index of suspicion is warranted and this disorder should be recognized early and treated. Hypothyroidism is also recognized in up to eight per cent of the general adult population. Complications following head and neck surgery in hypothyroid patients may be severe and include impaired wound healing, fistula formation and general deterioration (Talmi *et al.*, 1989). Although systemic complications of surgery in the hypothyroid patient are usually minor (Ladenson *et al.*, 1984), it is best recognized pre-operatively and treated in a timely fashion. All patients treated by surgery, chemotherapy, radiation or by combined modalities should always be screened for thyroid function.

Syndrome of inappropriate antidiuretic hormone (SIADH)

Increased secretion of arginine vasopressin (AVP) may accompany cancer of the head and neck although its clinical manifestation may be overt in only three per cent of cases (Talmi *et al.*, 1992). Clinical SIADH presents with normal adrenal, thyroid and renal function and with serum hypo-osmolality (<280 mOsm/Kg), urine concentration or specific gravity greater than expected for serum osmolality, absence of oedema and low serum albumin, creatinine and sodium levels (<135 mEq/L). SIADH may be found following neck dissection in 18–35 per cent of cases (Wenig and Heller, 1987; Mesko *et al.*, 1997) and may be a factor *in post*-operative morbidity. Although obtaining a pre-operative serum AVP level may be useful, it is expensive and not readily available. Prevention of peri-operative overhydration will usually eliminate the laboratory and clinical presentation of SIADH. Serum and urine osmolarity should be obtained in patients with unexplained hyponatremia.

Psychosocial implications (David and Barritt, 1982; Kunkel *et al.*, 1995)

The head and neck area is the centre of most communicative functions and the only origin for respiratory and digestive functions. Disfigurement is one problem encountered in the patient undergoing major ablative surgery but immediate and successful reconstructive procedures are often found lacking, especially in the early post-operative period.

Even isolated radical neck dissection is a disfiguring procedure, especially in the younger, thinner individual, and patients should be appropriately counselled on this matter. Another issue contributing to alleviating post-operative concern is describing to the patient and family all the expected scars and i.v. lines, drains, monitors, etc. If the possibility of elective post-operative intensive care stay is expected, this should be stressed to lessen concerns naturally rising under such circumstances.

Pain is one of the more frightening prospects for cancer patients, especially if they suffered from pain in the pre-operative period. Patients are concerned with the possibility of pain increasing after surgery and subsequent radiation therapy. Even in patients free of pain, fear of it is a major consideration. The physiological basis of cancer pain includes a variety of mechanisms while the psychological aspects include anxiety, fear, depression and a sense of hopelessness. The patients should be counselled that even when a major procedure is planned accompanying the neck dissection, it is usually surprisingly pain-free and that when painful, excellent measures are available to counter even the toughest pain without seriously affecting function.

Pre-operative evaluation

Major vessel involvement should be assessed by palpation and imaging including contrast-enhanced computed tomography (CT), magnetic resonance (MR), MRA (Endres *et al.*, 1995), ultrasound doppler and angiography when indicated.

Evaluate distant disease: this may be more common than appreciated, especially in patients with long-standing and advanced disease and low neck involvement. Chest CT may be necessary and bone scans indicated in the presence of musculoskeletal pain.

Adequate nutritional status Adequate nutritional status is a key factor in patient recuperation and overall well-being. Poor nutrient intake usually results from dysphagia and odynophagia and malnutrition itself is contributory to poor gastrointestinal function (Goodwin and Byers, 1993). If possible always enhance nutritional status. Consider percutaneous endoscopic gastrostomy (PEG) or open gastrostomy even in relatively small oral cavity procedures. This will help sustain nourishment in the post-operative period and overall is easier to tolerate than many days of nasogastric tube. If the patient's nutritional status is poor, it is advisable to delay a procedure, especially if extensive, to improve this condition and vitamin intake may be of value. If oral intake capacity is low, PEG may be performed pre-operatively to assist in food intake. When malnourishment is moderate, treatment should not be delayed but support should be initiated promptly.

Hgb level Transfusion allows us to undertake major procedures with associated blood loss, yet may cause morbidity in themselves as despite screening, communicable diseases may be transmitted. Also immunosuppression may be induced possibly leading to increased risk of infection or tumour recurrence. Need for transfusions may be increased in composite resection and mandibulectomy, especially in low haemoglobin patients with advanced lesions

(McCulloch *et al.*, 1989; Weber, 1995). Autologous blood transfusions are one answer and despite overall patient condition, 85 per cent of patients in one series met the criteria for it. It should be remembered that auto-donations can be obtained up to 72 hours prior to surgery and although only one unit may be donated per week, donations can be obtained with haemoglobin levels of above 11 g/dL and a haematocrit of 0.33 or greater (McCulloch *et al.*, 1989; Weber, 1995). Levine *et al.* (1986) studied blood loss and transfusions in surgery of the larynx and neck. Estimated blood-loss for isolated RND was 600 ± 420 cc. The authors propose a practical guide to the necessity of typing and screening with, or without, the need for cross matching. They recommend ordering 2 units whether the Hgb ranges from 10–12 gm/dl or even higher.

Dental status Always evaluate early and allow tooth extraction (if not full mouth tooth extractions) prior to the definite procedure if possible. In all cases where radiation is planned, oral surgery consultation is recommended.

Smoking cessation The issue of how long a time it takes to benefit from smoking cessation is not well established although even 12–24 hours may benefit the cardiovascular system, mainly from carbon monoxide and nicotine elimination (Pearce and Jones, 1984). A cessation of several days may greatly improve ciliary beating and two to six weeks would decrease post-operative respiratory morbidity. Psychologically, patients that smoke 'en route to the OR' would perhaps be better off left this way despite their somewhat high carbon monoxide and nicotine levels. It should be noted that post-operative smoking withdrawal symptoms are fairly uncommon. In heavy smokers we recommend awareness to possible withdrawal symptoms such as disorientation and agitation despite a wide differential diagnosis. In these cases we have successfully used Nicotinell TTS patches (Ciba Geigy). Continued tobacco use after treatment is a problem with up to 35 per cent of patients that smoke (Ostroff *et al.*, 1995). As this leads to increased incidence of tumour recurrence and second primary malignancies, compromising the ultimate goal of patient cure, efforts should be directed to assist patients in efforts of smoking cessation.

Alcohol withdrawal (Newman *et al.*, 1995; Spies *et al.*, 1995) Alcohol use among head and neck cancer patients is common and post-operative withdrawal symptoms may increase morbidity. Three clinical stages of alcohol withdrawal are recognized: minor, major and severe or delirium tremens. Minor symptoms occur usually within less than 24 hours and are manifested by nausea, anorexia, tremor tachycardia, anxiety, hyperreflexia and insomnia. Major symptoms usually occur between one to five days and are characterized by hyperactivity, disorientation, diaphoresis, hallucinations and fever. Delirium tremens is potentially fatal, occurs three to five days following cessation and is characterized by gross tremor, profound confusion, severe agitation, fever, incontinence, hallucinations and mydriasis (Newman *et al.*, 1995). Prevention is an achievable goal and may be obtained by either intravenous or enteral ethanol administration, benzodiazepines, clonidine and beta-blockers. No superior protocol was found (Spies *et al.*, 1995). Single agent use of either lorazepam or chlordiazepoxide was found to be effective (Newman *et al.*, 1995). These are administered 1–2 mg t.i.d. or q.i.d. and 25–50 mg t.i.d. respectively. We have very little experience with such patients in our country.

Avoid performing an incisional biopsy of a neck mass as part of the diagnostic process unless part of the definitive procedure. Even excisional biopsies tend to increase local complications and distant disease spread (McGuirt and McCabe, 1978; Parsons *et al.*, 1985).

Anaesthesia

It is important to communicate all relevant data and specific concerns to the anaesthesia team both before and during the procedure. Other than the obvious, this allows for a 'two way street' communication permitting you increased involvement in some aspects of the 'grey zones' between the two disciplines.

Thromboembolism prophylaxis

Pulmonary emboli and deep venous thrombosis are uncommon in neck dissection (Moreano *et al.*, 1998) and overall, decreasing mortality from pulmonary embolism may have resulted from increased use of anticoagulants. The most commonly used regimen is standard low-dose heparin 5000 U administered subcutaneously twice a day until the patient is ambulatory.

Theoretical advantages of low molecular weight heparin are lessening bleeding complications, prolonged duration of action and it is less likely to be associated with heparin-induced thrombocytopenia (Owings and Blaisdell, 1996). Low molecular weight heparin used for prophylaxis is Dalteparin (Fragmin®) or Enoxaparine (Clexane®). This is administered once a day, 2,500 U or 20 mg for low risk patients and 5,000U or 40 mg for high risk patients, respectively. Adjusted-dose heparin, elevating activated partial thromboplastin time (PTT) to five seconds above the upper limit of the normal was found to be the safest and most reliable regimen (Owings and Blaisdell, 1996).

External pneumatic compression, gradient elastic stockings or elastic dressings placed to thigh height are also employed as an important part of thromboembolism prophylaxis.

Fluid control is in the hands of the anaesthetist but the surgeon must be vigilant that over-administration of crystalloids may lead to increased peripheral and brain oedema, increase the likelihood of clinical SIADH, and pulmonary oedema and restricting fluids may compromise cardiovascular status and may lead to (rare) optic neuropathy and blindness (Strome *et al.*, 1997).

Preservation of body heat is vital. Make sure a heating mattress or blankets are available. It is better to turn on the air-conditioning only after the patient is covered and scrubbed. Warm i.v. fluids and ventilator gases if possible. Even mild hypothermia may lead to peripheral vasoconstriction, believed by some to compromise flap survival. Maintaining normothermia leads to decreased abdominal wound infection rates with shortening of hospitalization (Kurz *et al.*, 1996) and may decrease the incidence of morbid cardiac events (Frank *et al.*, 1997).

When working in the vicinity of the carotid bifurcation, injection to the adventitia is advisable as it can prevent hypotension, bradycardia and arrhythmia.

In laryngeal procedures the airway is naturally in our domain. It is advisable to control the cuff itself as well.

Prevention of decubiti is best achieved by padding of ankles and other likely spots of pressure. Special attention should be given to EKG leads and wiring, pulse oxymetry etc. This is especially important in prolonged procedures but also in isolated neck dissection in a patient prone for this problem such as elderly or undernourished patients with impaired peripheral circulation.

Post-operative stage

Hypertension may follow radical neck dissection, especially in the early hours or days. Immediate hypertension lasting up to two hours was reported (McGuirt and May, 1987). This was attributable to carotid sinus denervation (Celikkanat *et al.*, 1997) but hypertension may also be induced by Cushing's reflex associated with intracranial hypertension (Weiss *et al.*, 1993). If hypertension is encountered, its incidence is increased if the contra-lateral side is dissected later. This may induce bleeding and haematoma formation and should be regularly monitored and treated.

Prolongation of the Q-T interval was encountered following right-sided radical neck dissection (Otteni *et al.*, 1983) although results were contested elsewhere (Rassekh *et al.*, 1997). Special attention should be given to potassium levels in patients with prolonged Q-T. Avoid pressure on neck and flaps. If the patient is tracheostomized, suture the tracheostomy tube to the neck skin and avoid tying. Avoid dressing unless a pressure dressing is warranted. Dressing is time-consuming, masks haematoma, seroma or flap ischaemia, and has no benefit in avoiding infection. Clean wounds with hydrogen peroxide and apply antibiotic ointment to wound and drain sites. The patient's upper body should be placed at a 30° angle for 48 hours.

Initiate early aggressive respiratory physical therapy. Stress the importance of clearing secretions to the patient and family. Exercises should be performed regularly and if painful, should be timed to coincide with maximal effect of analgesics.

Early patient mobilization is an important factor in decreasing morbidity. Facilitating this by early urinary catheter removal and patient encouragement cannot be over emphasized. If shoulder function is impaired because of sacrifice or trauma to spinal accessory nerve, early physical therapy should be initiated.

Pain directly decreases patient well-being and influences patient ability to clear lung secretions and mobilization. Although neck dissection is not a painful procedure, more than 50 per cent of patients will suffer from pain in the early post-operative period. Unless the patient categorically denies any pain, analgesics should be *routinely* administered for the first 48 hours at least. Usually, early analgesic treatment allows for overall less potent analgesics.

In patients with tracheostomies, respiratory efforts may force air into the wound by penetrating inside the suture lines. It is advisable to inflate the cuff temporarily when performing respiratory toilet or physical therapy.

It should be noted that patient hospital stay after neck dissection has shortened following the diagnosis-related group reimbursement programme from a mean of 16 to 10 days without detrimental effects (Flynn *et al.*, 1990).

Special considerations

Bilateral neck dissection

Weber *et al.* (1994) studied the impact of bilateral neck dissection on recovery following supraglottic laryngectomy. This routine was started because of high (20 per cent) neck disease on the contralateral side. A slight increase was noted in blood loss and i.v. fluid administration. No significant difference was found in incidence or type of complications. Razack *et al.* (1980) showed increased mortality and morbidity in patients undergoing simultaneous bilateral neck dissections. However, no statistical analysis is provided. This series included 61 patients and covers the years 1966–1977. Operation on the contralateral side in staged procedures was delayed six to 12 months and mean blood loss per procedure was 4.1 litres. The most common complication encountered was facial oedema and swelling. Higher rates of infection and fistulae were seen in the simultaneous group and seven cases of carotid rupture occurred in the former while none in the latter. This could be accounted for by increased infection and fistula rates but also included other factors as well. Despite this, the authors suggest a one-stage procedure although they advocate the preservation of one internal jugular vein when feasible.

Weiss *et al.* (1993) studied intracranial pressure in four patients undergoing a staged second neck dissection three, four, 10 weeks and two years following the initial procedure. All patients developed transient intracranial hypertension and the authors recommend fluid restriction, hyperventilation, prevention of coughing and straining and additional measures if indicated.

McGuirt and McCabe (1980) describe 91 patients undergoing bilateral RND. Complications were greater for the simultaneous group but no deaths occurred and the authors encourage aggressive treatment where indicated.

We recommend the external jugular vein should be preserved if possible and raising the patient's head and administration of steroids and mannitol may be indicated. In all patients after radiation and especially in oral cavity and pharyngeal tumours in elderly patients, a tracheostomy should be performed.

The internal jugular vein was found to be thrombosed by post-operative imaging in 14–30 per cent of cases following modified neck dissection (Fisher *et al.*, 1988; Docherty *et al.*, 1993; Cotter *et al.*, 1994; Leontsinis *et al.*, 1995; Brown *et al.*, 1998). This may be associated with fistula, infection, flap use, and recurrent cancer.

From these data it is derived that probably a higher percentage of bilateral sacrifice of the internal jugular is actually incurred and this is to be considered in light of unilateral modified neck dissection with radical neck dissection on the contralateral side. Meticulous technique with prevention of excess drying of the preserved internal jugular and prevention of excess trauma will probably reduce the incidence of this occurrence.

Blindness due to ischaemic neuropathy was reported following bilateral radical neck dissection (Marks *et al.*, 1990; Wilson *et al.*, 1991; Schobel *et al.*, 1995). Yet, this uncommon catastrophe was reported also after staged or unilateral neck dissection (Wilson *et al.*, 1991; Schobel *et al.*, 1995).

Elderly patients

Improved monitoring and anaesthetic techniques allow for a similar treatment protocol for patients above the age of 70 years, depending on their physical condition and related disease. No significantly increased wound complications were encountered in elderly patients, although medical complications associated with concurrent illness rather than with age alone were more commonly seen (Barzan *et al.*, 1990; Kowalski *et al.*, 1994). Advanced patient age is also not a contraindication for free flap reconstruction (Shestak *et al.*, 1992).

The main consideration in an elderly patient should be his or her general condition and underlying disorders as are reflected in the practical time-proven ASA score (1963). General guidelines for this population would be to pre-operatively optimize physiological, medical and psychological status. Alterations in clinical presentation may be caused by presence of multiple disorders, relative inactivity, confusion, impaired communication and higher pain thresholds.

Specific intra-operative concerns are related to patient positioning and neck extension, increased skin fragility, increased risk for haemodynamic instability, myocardial oxygen supply–demand ratio, respiratory impairment and alterations in mental status. Post-operatively assist in maintaining cognition by ongoing assessment and stimulation and maximize mobility. Coordinate intensive care even in non-complex patients if undergoing prolonged procedures.

Post-chemotherapy and radiation

A higher incidence of complications is expected in these patients even when possible underlying disorders (hypothyroidism, nutritional status) are addressed. A higher incidence of complications, albeit minor were reported (Newman *et al.*, 1997). Parsons *et al.* (1985) found a higher incidence of flap and graft wound dehiscence with overall accepted levels without carotid blowout. No increase in free flap failure after radiation was noted (Bengtson *et al.*, 1993). No increased incidence of complications was reported by others as well (Cummings *et al.*, 1977; Lavertu *et al.*, 1998). In another series, major wound complications such as fistulae and flap necrosis with two attributable deaths occurred in 61 per cent of 18 patients undergoing salvage surgery after organ preservation failure (Sassler *et al.*, 1995). No increase of need for intra-operative blood transfusion was found in patients following radiation (Weber *et al.*, 1989).

Gentle flap handling with warm irrigations, and carotid covering are recommended. The patient should also be counselled on the possibility of extended stay because of wound breakdown or fistula formation.

Carotid blowout (Hillerman and Kennedy, 1982; Porto *et al.*, 1986; Leemans *et al.*, 1995)

Carotid blowout is associated with over 25–60 per cent morbidity and 35–50 per cent mortality rates. Neurological sequelae of ligation include contralateral hemiplegia, hemianaesthesia, aphasia, dysarthria, optic nerve atrophy temporal hemianopsia or monoplegia (Porto *et al.*, 1986). Increased incidence is seen following radiation and salivary fistulae. Damage to the adventitial layer by radiation or stripping during surgery is another contributing factor. Direct vessel involvement by tumour is uncommon per se but its presence may lead to rapid vessel wall breakdown and bleeding. Salivary control is important with controlled fistula when necessary. Even in non-extended neck dissection, care should be taken to ligate the lower part of the parotid gland if violated.

During surgery the following should be carried out: a) plan 'smart' flap elevation to minimize vessel exposure; b) if risk of exposure, cover vessel with muscle; cut low and rotate the levator scapula muscle or cover by dermal graft. In cases where a gastric pull-up procedure is utilized for hypopharyngeal reconstruction, we found transposed omentum creates an excellent carotid coverage. Dermal grafts used should be small to prevent fluid accumulation underneath and should be 0.12–0.14 inches thick (Yarington *et al.*, 1976). Despite the attractiveness of this concept of covering the vessel, the value of this technique is still controversial (Hillerman and Kennedy, 1982) and should probably be reserved to post-radiation cases.

If impending carotid blowout is suspected, immediate precautions should be taken: prepare blood, prepare bedside instrumentation and alert staff. Angiography with diagnostic or corrective balloon occlusion may be indicated with the appearance of 'sentinel bleeding'. Yet, ancillary diagnostic procedures such as EEG and ocular plethysmography are usually unfeasible in cases of imminent rupture. In imminent carotid exposure a pectoralis major myocutaneous flap or other vascularized flaps may be used for coverage. Adequate multiple i.v. lines should be secured and a central venous catheter should be considered.

In case of rupture, immediate local pressure should be applied. Raising blood pressure and haemoglobin level if achievable may reduce morbidity. Porto *et al.* (1986) recommend stabilization of blood pressure above 110 mmHg, pulse between 60–100 beats per minute and PO_2 over 70 mmHg. Ligation is recommended via two separate incisions and may be done under local anaesthesia.

Miscellanies

Anomalies of the carotid artery exist. Although the bifurcation is normally at the level of C3–C4 opposite the upper margin of the thyroid cartilage a low bifurcation may be encountered (Ord and Ward Booth, 1986).

Sternoclavicular joint hypertrophy was found to be a common occurrence following radical neck dissection (Cantlon and Gluckman, 1983). Mild to severe enlargement exists and as the lesions may resemble metastasis both on bone scan and radiographically, their presence may cause concern. If painful, treatment should include local heat and physical therapy. Myositis ossificans traumatica (post-traumatic bone formation) in the platysma following radical neck dissection was reported (Shugar *et al.*, 1981). If indicated, surgery should be performed six to 12 months following the initial trauma to allow for maturation of the lesion.

Surgical technique

Scrubbing and prepping

Asepsis prevents the contamination of surgical wounds. The goal in preparing a surgical site is to remove the transient and pathological bacteria and to decrease the resident flora to the lowest achievable level. Personal scrubbing guidelines such as meticulous cleaning of the subungual space, sufficient scrubbing time, use of appropriate antiseptic detergents, appropriate drying technique etc. are all obviously important and should be closely observed.

In cases where the surgical cuts are in proximity to hair-bearing skin, hair removal is unnecessary. Removal of hair is recommended only to provide exposure to the surrounds of the incision if so placed. There is no need for shaving of large areas for asepsis and doing so may even increase the rate of surgical site infections, especially if not done immediately prior to surgery (Beck, 1986; Small, 1996).

In order to achieve maximal reduction of bacteria level, the surgical prep should be a two-phased procedure. A detergent scrub should be performed with a combination of water and detergent-based antiseptic. An antiseptic should then be applied to the skin starting from the centre towards the periphery.

In clean-contaminated or contaminated surgery involving the oral cavity or hypopharynx, Betadine rinsing of the mouth (Redleaf and Bauer, 1994) or even topical antibiotic prophylaxis (Grandis *et al.*, 1994a; Grandis *et al.*, 1994b) are beneficial.

Although en-bloc resection of primary tumour with the neck specimen is considered the 'gold standard' this should be differentiated from in-continuity dissection and resection (Leemans *et al.*, 1991). If excising the whole specimen with preserved integrity is difficult, it should be avoided. In supraglottic laryngectomy, where bilateral neck dissection is the rule, excising the neck specimen with the tumour should be discouraged as it is at best pedicled only on the omo-hyoid muscle and fascia and prevents good access to the postero-lateral larynx.

'Submuscular recess' and level VI

The posterior supra spinal accessory nodes are an integral part of the defined level II (Robbins *et al.*, 1991). In a comprehensive procedure involving this level, the submuscular recess should be dissected. Recently, it has been shown that in selected cases with N+ and in N0 cases, dissection of this region can be obviated (Kraus *et al.*, 1996; Talmi *et al.*, in press). Elimination of this dissection reduces the chance of trauma to the XIth nerve and is time saving.

Level VI or the anterior compartment of the neck is readily excised with minimal morbidity and time. This level may be involved with tumour or metastases in cancer of the larynx, especially with subglottic extension, thyroid tumours and tracheal lesions. It was proposed that resection of nodes in this area reduces the incidence of post-laryngectomy stomal recurrence (Hosal *et al.*, 1993). We recommend resection of level VI in all cases of midline neoplasms, laryngeal and thyroid tumours and in all cases of N+ involving levels IV and/or V.

Nerves

Reparative processes of transected nerves may lead to neuroma formation occurring in the early or late post-operative period. Neuromas are usually very tender and painful and may mimic recurrent disease. In order to eliminate neuroma formation, various techniques were advocated including ligation of the cut edge, cautery, alcohol injection or even burying the cut end in muscle tissue. None of these techniques have any proven value but fortunately, neuromas following neck dissection are uncommon.

The spinal accessory nerve (SAN) has two components: the spinal part arises from the lateral part of the anterior horn of the cervical spinal cord while the cranial part arises from the lower part of the nucleus ambiguus. The cervical root enters the

skull through the foramen magnum and passes to the jugular foramen. After exiting, it passes downwards to the upper part of the SCM. On piercing the muscle it communicates with the branch to the muscle from the second cervical nerve. The nerve then crosses the occipital part of the posterior triangle and enters the undersurface of the trapezius where it joins C3 and C4.

Shoulder function after radical neck dissection is known to be impaired because of the damage to the SAN (Fialka and Vinzenz, 1988). Abduction is limited, pain and stiffness are common, and the classic description also includes aberrant scapular rotation and abnormal EMG activity with normal radiological findings. This may also be encountered, albeit to a lesser degree, following modified neck dissection with preservation of the spinal accessory nerve. The findings of shoulder impairment with normal or slightly decreased trapezius muscle activity have been attributed to adhesive capsulitis or the frozen shoulder symptom (Patten and Hillel, 1993). Shoulder dysfunction was still found even in modified neck dissection with nerve sparing consistent with a degree of nerve damage.

In earlier times, the SAN was always sacrificed as part of the neck dissection procedure. It has been shown that unless grossly involved by disease or in close proximity to it, the nerve can safely be preserved without jeopardizing the integrity of tumour extirpation (Brandenburg and Lee, 1981).

Preservation of the nerve also includes prevention of inadvertent damage to this structure and several techniques have been advocated (Becker and Parell, 1979; Eisele *et al.*, 1991; Sheen *et al.*, 1997).

Care should be taken when elevating the skin flaps as occasionally the SAN is quite superficial. The distinctive anatomical landmarks related to the nerve are Erb's point and the transverse process of the atlas. Erb's point is the bundle of sensory nerves plexus emerging from the posterior aspect of the sternocleidomastoid (SCM) midway or somewhat above the middle of the muscle. According to one technique, an imaginary line is drawn from this point to the thyroid notch. The SAN will exit the posterior border of the SCM 1–2 cm above this line (usually 3–5 cm or two finger-breadths above the clavicle) and enters the trapezius muscle 2 cm below it. Care should be taken at this dissection to delineate the anterior border of the trapezius as following the SAN by dissection may lead underneath the muscle. Another technique of finding the SAN is at the medial surface of the SCM at the upper part of the neck. Another suggestion is finding the nerve following an imaginary line connecting the angle of the mandible with the acromion. A practical approach if elevation of the posterior skin flap is performed with a Bovie in a non-paralysed patient, is allowing shoulder 'jumping' to clearly and quite safely point to the approximate area of the nerve. The transverse process of the atlas is easily palpated and the SAN may be found in this region anterior to it, in proximity to the internal carotid artery and overlying the internal jugular. Once the insertion of the nerve into the SCM is traced, the muscle overlying the nerve is cut, allowing for its full-length exposure. At this point, the nerve is best left adherent to the underlying structure to minimize trauma and is released only after its whole course has been exposed. The nerve should be elevated with a nerve hook with minimal traction. If the nerve is sacrificed or inadvertently cut, there may be value in anastomosing or cable grafting the nerve with the great auricular nerve (Weisberger *et al.*, 1998).

The ansa cervicalis is derived from the superior root (C1 and C2) and inferior root (C2 and C3) and innervates the infrahyoid muscles; omohyoid sternohyoid, sternothyroid, thyrohyoid, and geniohyoid. The nerve originates at the point where the hypoglossal hooks around the occipital artery and passes down over the carotid sheath joining in a loop with branches from C2 and C3. The ansa is usually sacrificed but may be preserved occasionally.

The cervical plexus (C1–C4) carries sensation from the skin of the neck, the ear and behind the ear. Sacrifice of part or most of all cervical branches may be avoided in modified neck dissection but usually occurs in radical neck dissection. Lack of sensation may seem to be the last worry to the patient at the time of diagnosis and ablative surgery but often becomes the only reminder of the procedure apart from the scar afterwards. Avoiding damage to the great auricular nerve takes some effort but may be worthwhile in modified neck dissection. The patient should be counselled on these possible consequences including estimated duration of lack of sensation.

The hypoglossal nerve carries also branches of C1 and innervates the intrinsic and extrinsic muscles of the tongue except for the palatoglossus. The nerve passes through the anterior condylar canal then downwards between the vagus and accessory nerves and between the internal carotid and internal jugular to the lower border of the digastric muscle. It then curves around the occipital artery and crosses the external carotid and lingual arteries and passing between the mylohyoid and hyoglossus muscles ends by dividing into branches on the genioglossus. The hypoglossal nerve may occasionally be found more cephalad than expected, especially in patients with former neck procedures and scarring. The nerve is best identified crossing the carotid bifurcation but could also be found by way of tracing upwards of the ansa hypoglossi or searching in the area of the tip of the hyoid bone. Anomalies of the carotid artery may not necessarily reflect similar anomalies of the nerve course but caution is warranted in these uncommon cases. It should be well remembered that unless intentionally sacrificed, damage to one nerve is an avoidable unpleasantness whereas bilateral damage is catastrophic. Pre-operative evaluation should always include tongue mobility and sensation, especially in cases with oral cavity tumours and high neck disease.

The lingual nerve is derived from the mandibular division of V3 and carries sense from the anterior two thirds of the tongue and floor of the mouth. The

nerve lies medial to the lateral pterygoid muscle; it then passes downwards in front of the inferior dental nerve and is joined by the chorda tympani. It then passes between the medial pterygoid and ramus of the mandible under the superior constrictor of the pharynx. It then courses above the posterior edge of the mylohyoid and runs antero-medially to dip below the submandibular duct on the surface of the hyoglossus. The lingual nerve may be prone for damage in dissection of neck level I. Its course along the Wharthon's duct should be recognized and this easily identified structure preserved.

The marginal mandibular branch is derived from the cervicofacial division of VII to the orbicularis oris, depressor anguli oris, depressor labii inferioris, mentalis, and to some extent, the platysma muscle. The nerve descends below the angle of the mandible and crosses the inferior border of the jaw on the facial artery. Techniques of preserving the nerve are subsequently described.

The phrenic nerve is derived from the ventral primary rami of C3–C5 (cervical plexus), gives off pericardial branches and innervates the diaphragm. The nerve lies in front of the scalenus anterior muscle and descends medially on it in front of the subclavian artery to enter the chest. The fascia overlying the anterior scalenus can on occasion be left intact. The contributing branches to the phrenic nerve should be cut sharply rather than by Bovie, several centimetres from where they join the nerve and should be pulled down towards the nerve thus minimizing trauma to it from manipulation of the nerves close to the phrenic. Transient or permanent trauma to the phrenic nerve will usually manifest only on X-ray but if a severe pulmonary problem exists, especially with a pectoralis major flap harvest, respiration may be compromised. Bilateral phrenic paralysis is a severe complication and may lead to respiratory failure and the need for mechanical ventilation, especially in the early post-operative period.

The carotid plexus of the sympathetic trunk innervates vascular smooth muscles, erector pili, sweat glands of upper neck and face, vascular smooth muscles of orbit, forehead, upper nasal cavity, and dilator pupillae. The sympathetic trunk is at risk of incurring injury, especially in modified neck dissection when the great vessels are unwrapped and the retrovascular space can be entered. Horner's syndrome is encountered occasionally after neck dissection but should and can be easily avoided by recognizing the retracted tissue orientation (Collins, 1991). Damage to afferent and efferent sympathetic fibres may also result in a prolonged Q–T interval with resulting tachyarrhythmias (Otteni *et al.*, 1983).

The brachial plexus lies between scalenus anterior and medius, crosses the posterior triangle and descends behind the clavicle. This stucture is usually not encompassed in neck dissection but knowledge of its location is important in preventing a major but readily avoided complication.

The vagus nerve descends vertically in the carotid sheath, posteromedial to the internal jugular and posterolateral first to the internal carotid artery and then to the common carotid artery. The vagus may be damaged in any neck dissection but is more prone in a radical neck dissection during ligation of the internal jugular. This complication should not occur and is readily avoided. The nerve can usually be visualized with minimal dissection and its exclusion verified. An alternative technique is by palpation while being ready to clamp the internal jugular. The vein is grasped between two fingers and if the nerve is adherent to it, its cord-like structure is palpated and damage avoided.

Incisions

A variety of flaps exist for neck dissection (Robbins and Oppenheimer, 1994). In some situations, flap design is derived from the surgical procedure or in cases where skin overlying tumour is to be excised. In the simple neck procedure, incisions should be adapted to suit the procedure, former scarring, cosmesis and personal preferences of the surgeon. The vascular supply to the neck skin has been shown to be derived from the external carotid artery superiorly and the subclavian artery inferiorly. Yet, the bipedicled flap (McFee) can safely be used (Doberneck, 1973; Daniell and Fee, 1987; White *et al.*, 1993). If guidelines preventing trifurcations and other compromising of the vascular supply are avoided, a rather wide range of incisions may be used even if not all are standard procedures.

Incisions should be placed so they allow maximal exposure and a 'way out' should there arise a need for extending the operation i.e. to posterior neck dissection, other levels or contralateral neck.

Flap elevation

The key is good planning and meticulously careful handling. If a tracheostomy is performed, the problem of its being incorporated in the main surgical field arises. Even in a clean-contaminated procedure, asepsis is not the only major consideration but also the inability to preserve vacuum for drains at closure. In such cases involving one side only, we still make a horizontal tracheostomy skin cut for better cosmesis, but begin it in the midline and extend it to the contralateral side. The underlying structures are then easily undermined to the correct plane and location but this way, 1–2 cm of muscle and fascia are left intact ipsilaterally. This allows in many instances, better separation between the tracheostomy site and the neck dissection. If possible, place the incision in the skin creases or excise former scars, and if possible, separate the incision for tracheostomy from the main incision. Handle tissue with sharp instruments. Use of the Bovie in the 'Blend' mode in range of 20–20 setting is safe even for thin and dry skin.

The tissue should be incised in stages and refrain from elevating a bilateral flap from the start. Cover flaps with warm moist gauze, and before closure trim 2–3 mm of flap edges, evert edges and avoid incisions

paralleling the carotid artery. If working at a given part of the wound for some time, consider releasing flap retraction in the opposing site.

Submandibular triangle (Level I) (Stern, 1992; Ichimura *et al.*, 1997)

The submandibular triangle is excised in many neck procedures. It contains the submandibular gland, lymphatics, blood vessels and nerves (lingual n., lingual ganglion and hypoglossal n.). Accessing this region while elevating the superior flap of the neck dissection carries risk to the marginal mandibular branch of the facial nerve.

In order to minimize damage: assess patient preoperatively for ptosis of the glands (this tends to occur in elderly patients with perhaps some inferior displacement of the nerve). Apply meticulous haemostatic technique and avoid careless use of electrocautery. Place the incision low, and elevate fascia from inferiormost portion of the gland, skeletonize the gland and tack upwards on the fascial edges only. Identify the facial (retromandibular vein) ligate it, leave long suture for retraction and dissect the gland. If possible, avoid enthusiastic efforts to identify nerve.

Note: if the nerve is to be sacrificed in a lip-split incision, tonus of the contralateral side will pull the lip laterally thus resulting in an incision that is not in the midline. The lip-split incision should be placed on the contralateral side in advance so to appear in the midline or in proximity to it, later.

Minimizing blood loss

Minimizing blood loss is one of the keys to better surgical outcome and is ensured by both active and passive measures. Hypotensive anaesthesia has been examined as a potential for reducing intra-operative blood loss but this may be problematic in the usual head and neck cancer patient with atherosclerotic disease and other underlying disorders. A good history is important for ruling out coagulopathies. Use of aspirin and its derivatives is considered by some as a contra-indication for surgery if taken 14 or even 10 days prior to the scheduled time. We are not adamant about this but knowing about aspirin use in advance is important. Coagulation studies should be obtained and blood should be crossed and matched.

Proposed marked cuts should be injected with 1:100,000 bupivacaine 5 mg/ml and adrenalin in a superficial plane. The injection is best performed via a 21 or 22 needle and not smaller. It is safe to inject before the actual scrubbing and doing so allows for adequate vasoconstriction and minimization of blood loss from small vessels. If the patient's condition does not permit use of adrenalin, even injection of 1:100,000 bupivacaine 5 mg/ml may influence bleeding by pressure in the sub-cutaneous level and may be of value. Pending anaesthetic considerations, the patient should be placed in the reverse Trendelenburg position. Extensive use of the Bovie in the blend mode (usually in the 20–20 Watt range) using the *cut* button allows for a dry field. The standard paddle electrode is preferable to the needle tip, both for better dispersion of the electrical field by the former and the possibility of inadvertent damage by the latter. Proponents of Bovie knife use find it effective in reducing blood loss in routine major ablative head and neck surgery (Weber *et al.*, 1989; Bateman *et al.*, 1996). Even the smallest and insignificant bleeder should be coagulated and the 'right now' approach is the best. When working on or around a moderate to large size vessel, it is useful to have control of it at one point, at least, even if its resection is not planned. Clamps should be placed nearby and if a vessel is grasped it best be ligated immediately. Leaving a bunch of clamps for later is messy, occludes the field, and some are prone to be detached either causing increased bleeding or no bleeding induced by pressure, only to become reactivated later when blood pressure increases or a vessel spasm passes and it reopens.

Knowledge of the anatomy is important. The presence of small plexuses and vessels prone to bleeding should be recognized and avoided.

When tying an artery, it may be advisable to suture ligate it over or distal to the suture to prevent knot slippage. This is certainly the case in major vessels including the internal jugular vein, at least in its distal portion. The facial artery and thyroid arteries are other vessels where application of suture ligation was never regretted.

Knot slippage from the distal end of the internal jugular vein is avoided by double ligation of the vein with silk 0 and suture ligation of the stump with 3–0 atraumatic silk suture. If a tear or slipping of the knot does occur, there is a risk of air embolus (see following). If bleeding occurs following ligation of the proximal end of the internal jugular vein, it should be recognized immediately and treated without much difficulty as it is a low-pressure system. If efforts to grasp the end of the vessel fail, localized pressure application with rotation of a muscle flap with pressure will usually suffice.

Internal jugular vein blowout has also been recognized (Timon *et al.*, 1994), with predisposing aetiological factors similar to those of carotid rupture such as pharyngo-cutaneous fistula. Internal jugular vein rupture should be distinguished from carotid blowout and treating this condition is less difficult carrying a far better outcome but although similar to the latter, it constitutes a medical emergency.

Air embolus

Large visible bubbles of air in the internal jugular vein are not an uncommon finding (Rice and Gonzalez, 1992). Air embolus is a rare event occurring following an internal jugular tear or cut with sucking of air. If a tear or cut occur, apply immediate local pressure. Diagnosis is based on a sudden fall in end-tidal carbon dioxide and a drop in arterial blood pressure. Precordial Doppler probe may pick up the characteristic murmur of venous air embolism. If an air embolus is suspected, notify the anaesthetist, place the patient in the Trendelenburg position, rotate on left side and discontinue nitrous oxide and ventilate with 100 per cent oxygen.

Attempts may be made to aspirate air from the right heart if a catheter is in place. Venous return may be increased by use of a G-suit. Hyperbaric oxygen therapy where available is the ultimate and effective treatment.

Pneumothorax

This may be caused by over inflation, especially in one-lung intubation. Pneumothorax may also occur when working low in the neck with a high lung apex. If a tear occurs in the pleura, its presence should be recognized and the tear should be sutured. Checking for a leak should be carried out in the Trendelenburg position with hyperinflation of the lung with irrigation of the area with clear fluid to observe bubbles. A chest X-ray should be obtained on the table so that a chest drain may be inserted if necessary.

Chyle leak (Thawley, 1980; Gault, 1987; al Khayat *et al.*, 1991; de Gier *et al.*, 1996)

The thoracic duct arises from the cisterna chyli at the level of the second lumbar vertebra rising into the neck between the aorta and the azygos vein. At the level of the thorax, the duct crosses to the left where it lies behind the aortic arch and the left subclavian artery and crosses the anterior scalene muscle and the phrenic nerve. The duct then terminates most commonly in the left internal jugular vein or in the left subclavian vein, left external jugular vein, left innominate vein or right jugular vein. Eleven to 45 per cent of patients exhibit more than one termination of the duct. The right lymphatic duct drains a part of the right side of the body and terminates at the junction of the right subclavian vein with the right internal jugular vein. Chyle flow ranges between 2–4 litres per day and leakage may produce significant metabolic disorders secondary to the loss of fluid, electrolytes and protein. Chyle accumulation may also compromise flap survival. Chylous fistula occurs in one to two per cent of neck dissections whereas chylothorax or chylo-pharyngeal fistulae are rare.

The key to treatment of a chylous fistula is prevention. Again, knowledge of the anatomy and the ability to recognize the small, somewhat translucent vessels is important. It is also important to remember that chyle in the fasting patient is clear-yellowish and not the characteristic milky-white fluid. If the duct is visualized during surgery it may be safely cross-clamped and tied. If dissection is possible without damaging the duct however, it is best left intact. If a leak is clearly identified during the dissection, its origin should be traced and it should be ligated with 4–0 silk. Even if the leak is controlled or even if no leak is evident, once the procedure is finished and prior to closure, the patient should be placed in the Trendelenburg position and positive pressure should be maintained by lung hyper-inflation. Even a minuscule leak should be repaired. Magnification may be used.

Post-operative chyle leak after the surgery is usually identified when oral feeding is started and the fluid sample obtained should be sent for fat content analysis. If a fistula is suspected, oral or nasogastric tube feedings should be discontinued and the patient should be maintained on intravenous feedings. The patient's head should be kept elevated and pressure dressings applied. Electrolytes and serum proteins should be monitored regularly. If fluid accumulation is reduced, no further treatment is called for and no bed rest is necessary. If flow continues and is above 300–600 ml per day, feeding with medium chain triglycerides (MCT), absorbed directly via the portal system should be started and local pressure application continued. If no improvement is evident the wound should be re-explored with the aid of magnification and following intake of a high fat fluid through the nasogastric tube or feeding enterostomy.

Drains

Avoid direct contact between vessels and drains. The drains usually used are the closed suction drains, Hemovac and Jackson-Pratt, as these systems decrease the incidence of proximal infection occurring secondary to drain contamination. The silicone material is less irritating to the body and is less likely to cause infection. Placing of drains should be carried out separately from the main incision as refraining from doing this may predispose to infection. Place drain cuts as lateral as possible to maximally mask scarring. Special attention should be given to avoiding having drain holes in proximity to the skin exit point as this may lead to loss of vacuum with even minimal manipulation. It is advisable to have separate vacuum containers for each drain as this allows easier removal of a drain without compromising the other(s). Drain sutures should be of synthetic material such as monofilament polyamide which although slippery, minimizes local skin reaction. Remove drains when daily amounts reach 20 cc unless other factors are involved.

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