Chapter

Reconstruction of Pharyngeal Defects

Takako Yabe and Bruce Ashford

Abstract

The management of pharyngeal defects is one of the most challenging tasks for reconstructive surgeons. The reconstructive method is driven by the amount of tissue loss as well as patient-related factors. Since the advent of organ preservation strategies in the 1990s as described by the Department of Veterans Affairs Laryngeal Cancer Study, salvage surgery has become a common pharyngeal procedure to obtain local control when nonsurgical treatment fails. This chapter is divided into preoperative, intraoperative, and postoperative phases of patient management. Each section will focus on particular aspects of management that are essential to achieve the best therapeutic outcome for patients who need pharyngeal reconstruction.

Keywords: head and neck reconstruction, pharynx, hypopharyngectomy, pedicled flaps, microvascular free flaps

1. Introduction

The pharynx is a muscular column that begins posterior to the nasal cavity, descends inferiorly behind the oral cavity before merging with the larynx and the oesophagus. It is subdivided into nasopharynx, oropharynx and hypopharynx (laryngopharynx) based on their anterior relations. Its primary functions are both digestive and respiratory where it creates the passage for air, solids, and liquids from the nose and mouth. Hypopharynx guides food into the oesophagus and pharyngeal muscles further support deglutition and speech.

Oncologic management of the pharynx presents complex challenges for both ablative and reconstructive surgeons. The move away from surgical management of both laryngeal (VA study) and pharyngeal malignancy has meant that many patients eventually presenting to surgery do so in a salvage setting. With the advent of transoral robotic surgery (TORS), a reframing of the role of surgery in the management of pharyngeal malignancy is underway. The results of Eastern Cooperative Oncology Group (ECOG-ACRIN 3311) may prescribe an increased role for TORS and impact on reconstructive strategies. ECOG-ACRIN 3311 examines reduced postoperative therapy in patients with "intermediate risk" p16+ oropharynx cancer (OPC) undergoing primary transoral surgical management. E3311 was a phase II randomised clinical trial of transoral surgery followed by low- or standard-dose, risk-adjusted post-operative radiotherapy with stage III-IVa (AJCC 7th edition) HPV associated oropharyngeal cancer (OPC). In this chapter, we will outline the range of requirements for pharyngeal reconstruction, and to outline the options for the surgeon managing pharyngeal defect reconstruction.

The 5-year survival rate of pharyngeal squamous cell carcinoma (SCC) depends on tumour stage and human papillomavirus (HPV) status. Up to 60% of patients die within three years [1]. However, beyond oncologic outcomes, functionality and quality of survival is an important determinant of therapy. The physiologic cost of surgery needs to be balanced against the well known long term effects of non-surgical therapies. The role of the reconstructive surgeon is to manage short term perioperative problems and long term functional outcomes to achieve the optimal quality of life result for the patient [2].

The practice changing Department of Veterans Affairs Laryngeal Cancer Study was a prospective, randomised study in patients with previously untreated advanced (stage III or IV) laryngeal squamous carcinoma. This study compared the results of induction chemotherapy followed by definitive radiation therapy with those of conventional laryngectomy and postoperative radiation [3]. A significant finding of the study was that chemoradiation successfully preserved the larynx in 64% of the patients. They achieved this result with a 2-year survival rate equivalent to that of conventional laryngectomy and postoperative radiation therapy [3]. The Intergroup Radiation Therapy Oncology Group 91–11 (RTOG-91-11) study evaluated the contribution of chemotherapy added to radiation therapy for larynx preservation. It also documented that concurrent chemoradiotherapy for the treatment of advanced laryngeal carcinoma conferred the highest rate of organ preservation at 84% [4]. These landmark trials have effectively relegated the role of total laryngectomy to those cases where there is no organ function to preserve or are in the salvage setting with extra-laryngeal spread [5].

The extent of defect determines the extent of reconstruction required. For small pharyngeal defects, primary closure or healing by secondary intention with the acceptance of some distortion of the local pharyngeal contour might be acceptable in the non-salvage setting. Post radiation granulation or primary repair, regardless of the defect size, is an unpredictable clinical scenario which should be avoided. Rates of pharyngocutaneous fistula (PCF) are related to the size and complexity of the defect and prior (chemo)radiation. The incidence of PCF range from 9–23% depending on the clinical context [6]. It is the avoidance of PCF which mandates a nuanced approach to the management of the post-ablation pharynx and that is a primary determinant of early post-treatment quality of life. Reconstruction of pharyngeal defects with free tissue transfer or well vascularised regional tissue [7] is considered the preferred choice in the salvage setting [8]. Chemotherapy is known to affect the function of neutrophil, macrophage, as well as B-cell and T-cell functions, resulting in impaired cellular and humoral immunity [9]. Wound healing potential is further compromised by radiation-induced obliterative endarteritis and fibrosis [10]. Salvage surgery often necessitates a broad field extirpation of the neck and upper mediastinal tissues that results in bilateral carotid artery exposure. Deficient wound healing caused by both chemotherapy and radiotherapy predisposes this patient population to development of pharyngocutaneous salivary fistula and life-threatening vessel rupture from salivary contamination and sepsis [6].

The recent history of head and neck reconstructive surgery can be traced back to the early twentieth century with axial patterned island flaps, split-thickness skin grafts, and regional flaps [11]. Flaps generally refer to tissue reconstruction with an intact blood supply, whereas grafts imply a non-vascularised transfer of tissue. Microvascular free tissue transfers (flaps) are further differentiated from regional flaps that their vascular supply is temporarily disconnected from the systemic circulation to be transplanted to a recipient site. Free flap surgery gained popularity in the latter half of the twentieth century [12].

2. Pre-operative considerations: goals and planning

All forms of treatment for these pharyngeal/pharygolaryngeal malignancies carry considerable toxicity, particularly to deglutition [13, 14]. Surgery, which is increasingly used to salvage failures of organ-preservation therapy [15], has considerable morbidity and mortality [16, 17] more so than for any other type of head and neck cancer [18]. The complexity of care in the salvage setting is difficult to overstate.

Primary goals of reconstruction of pharyngeal defects are maintenance of integrity, restoration of function and form, minimising morbidity, and improving quality of life [19]. The reconstruction needs to be able to withstand adjuvant radiotherapy but be compliant enough to restore a range of three-dimensional defects [20].

The gold standard of reconstruction should be a one-stage procedure with the lowest morbidity, a short hospital stay, early recovery of swallowing, and the restoration of a socially acceptable appearance [2]. Given the aim of getting the patient to adjuvant therapy, achieving the seal of the pharynx to allow for the restoration of enteral feeding and avoidance of neck sepsis is crucial [21]. Precise preoperative planning, including thorough comorbidity evaluations, is mandatory in these patients. Preoperative nutritional assessment and optimisation and the normalisation of other systemic diseases, including particularly hypothyroidism are essential before any effort at pharyngeal reconstruction.

The reconstructive ladder describes an increasing complexity of options: healing by secondary intention, primary closure, grafts, local flaps, regional flaps then distant flaps [19]. The simplest surgical option may not necessarily be the best surgical option because it does not take into consideration the goals of reconstruction [22].

In the situations where all of the reconstructive goals cannot be satisfied, they should be prioritised in the following order as mentioned below [19];

1. Maintenance of the integrity of head and neck tissues and aerodigestive tract with isolation of the intracranial content.

2. Restoration of the form including facial contour, consistency, and dimension.

3. Minimisation of anaesthesia exposure, complications, and morbidity.

4. Improvements to the quality of life.

The seven principles of pharyngeal reconstruction are as follows [23];

1. Single-stage reconstruction

2. Restoration of deglutition

3. Restoration of speech

4. Toleration of radiotherapy

5. Successful reconstruction in a heavily irradiated field

6. Minimal morbidity at the donor site

7. Minimal morbidity at the reconstruction site

Reconstructive options should be explored and discussed during the planning phase before ablative surgery based on the following principles [19];

1. Surgical defect

2. Anatomy

3. Surgeon expertise

4. Surgical facility

5. Reconstructive goals

6. Patient factors (i.e. comorbidities, body habitus, cancer prognosis, history of radiation and surgery, family support, and personal wishes)

Within reason, and subject to unforeseen intraoperative requirements, the reconstructive plan should be well understood by both the ablative and reconstructive teams. The ablative surgeon needs to appreciate the need for vessel preservation (in the event of free flap for reconstruction) and also needs to communicate any changes to the plan so that the reconstructive team can pre-empt modifications that might be required. The surgical management and reconstruction of the vessel depleted neck are of a particular challenge, and this problem should have been at least known preoperatively [24].

3. Intra-operative considerations

3.1 Pharyngeal defect

The extent of pharyngeal defect after resection can range from a small tonsillar or sidewall defect to a circumferential defect resulting from laryngopharyngectomy. Smaller defects in the primary setting can be managed by secondary intention without any sophisticated reconstruction. Larger defects or those in the post-radiation setting are more likely to benefit from active efforts to re-establish the pharynx.

Defect type can be classified according to the amount of residual mucosa [25].

1. Defects not requiring closure

2. Defects with sufficient pharyngeal mucosa to close primarily

3. Defects where a strip of pharyngeal mucosa remains but is insufficient to close on itself

4. Complete circumferential defects where a 360-degree segment of pharyngeal mucosa is lacking

Hui et al. demonstrated that primary closure can be achieved with acceptable swallowing outcomes with a minimum of 1.5 cm of relaxed or 2.5 cm of stretched pharyngeal mucosa remaining [26]. In circumstances where there is sufficient mucosa to close a pharyngeal defect primarily, the current evidence generally favours onlay vascularised tissue over the suture line to reduce the rates of fistulation [10, 27].

A circumferential defect with the reconstruction of a neopharynx would, in most cases, be best managed with free tissue transfer, either as a "tubed" anterolateral thigh or radial forearm free flap or using some component of the alimentary tract such as the stomach or small bowel (**Figure 1**) [25].

3.2 Technical considerations

In a recent review on managing pharyngeal defects, Ragbir et al. indicated that pharyngeal defects with more than 3.5 cm of residual pharyngeal mucosa may be closed primarily, defects with less than 3.5 cm of residual pharyngeal mucosal width require interpositioning replacement with imported tissue, and circumferential pharyngeal defects require circumferential reconstruction.

Primary closure of pharyngeal defects can be performed in vertical, horizontal, or T shaped orientations. The ideal technique for closure and the resultant fistula rates have been intensely debated. Pioneering work by Su and Chian [28] advocated placement of the T-shaped suture line. Cho et al. [29] suggested a modification to the flap design by overlapping the vertical suture line with de-epithelialised skin and using a two-layered closure with triangular flaps at the distal anastomotic site. Although no consensus has been reached, it is important to remember the principles of closure; the approximation needs to be watertight with just adequate approximation to avoid compromising the vascularity of the suture line [30]. As with all tissue closures, tension should be avoided.

Where primary closure cannot be achieved safely, or in cases where primary closure has been possible in the salvage/post radiotherapy context, either coverage or augmentation of the closure with either a regional flap or a free tissue transfer may be necessary.

3.3 Flap choices

Most soft tissue flaps are designed to be 10 to 20% larger than the defect itself to accommodate for tissue shrinkage [19]. They can be pedicled or microvascular free

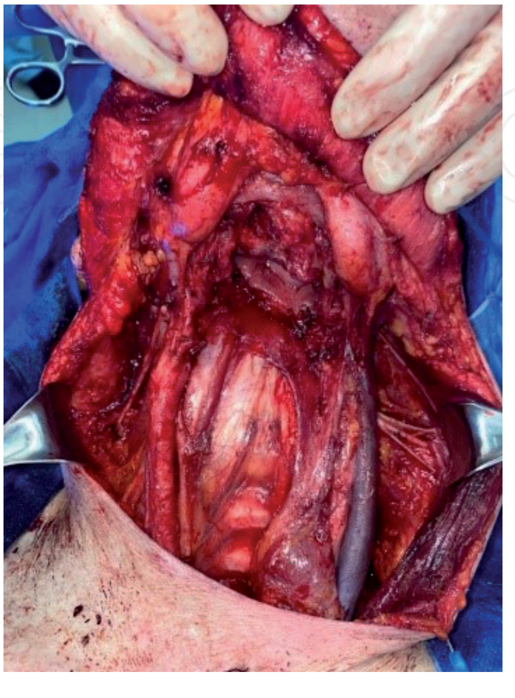

Figure 1.
Defect following salvage total pharyngolaryngectomy.

flaps depending on the nativity of their blood supply. Their advantages and disadvantages are discussed below.

3.3.1 Regional pedicle flap options

3.3.1.1 Pectoralis major myocutaneous flap

The pectoralis major (PM) flap was first described by Ariyan [31] in 1979. In the setting of pharyngeal defects, it can be grafted to a defect with or without a cutaneous component. Inset of an area of skin into a pharyngeal defect allows for a more robust seal to be achieved early. Without skin, the muscle flap can be used to seal a defect or to onlay over a primary pharyngeal closure. Using the PM pedicled flap as an onlay flap has been shown to decrease the rate of pharyngocutaneous fistula when compared to primary closure alone [32].

With a circumferential pharyngeal defect, the PM flap can be sutured directly to the prevertebral fascia or with a split-thickness skin graft relining the prevertebral fascia [33]. More commonly, the PM flap is used as a patch repair to reconstruct the anterior pharyngeal wall in cases where only the posterior wall remains [25].

Advantages include a relative ease of harvest and reduced operating time when compared to free tissue transfer. Moreover, the PM flap is a robust and reliable option that obviates the need for microsurgical anastomosis, which is particularly relevant in a vessel-depleted neck. The disadvantage of such a bulky flap is that it can create tension on the tongue which may limit tongue mobility, impairing speech, articulation and swallowing function. Even if the muscle is denervated, the relative bulkiness of the muscle often persists and this can also impede tracheoesophageal speech by impairing the vibratory quality of the neopharynx [25]. Voice outcomes after PM flap reconstruction of the pharynx are shown to be inferior to those of primary closure alone [34].

Donor site morbidities, including shoulder and arm dysfunction as well as chest wall contour deformity are significant and debilitating. The muscular bulk of the flap can also distort the stoma, making the use of a voice prosthesis more challenging [35].

The PM pedicled flap is usually limited to the medically comorbid patient who would not otherwise tolerate the prolonged operating time under general anaesthesia required for a free flap. It is often utilised as a back-up flap in circumstances where wound breakdown compromises any initial pharyngeal reconstruction [25].

3.3.1.2 Supraclavicular artery island flap (SCAIF)

The SCAIF is a pedicled fasciocutaneous flap based on the supraclavicular artery and vein. These vessels arise from the transverse cervical vessels and this flap can be used for a multitude of head and neck reconstructions where a thin and pliable replacement is indicated [36]. Up to 20% of patients will not have the branch of the transverse cervical artery (TCA) [37] and preoperative audible doppler will allow for assessment of this vessel as it runs over the lateral clavicle into the deltoid region. Emerick et al. reported their experience using the SCAIF in reconstruction following total laryngectomy [35]. A benefit of the SCAIF is its ability to reconstruct the anterior neck skin, which may be necessary in the setting of salvage laryngectomy [35].

3.3.1.3 Internal mammary artery perforator flap (IMAP)

The IMAP is supplied by the first 3 or 4 branches of the internal mammary artery. It is raised in a subfascial plane to within 2–3 cm of the sternal margin. The flap is raised as an island to allow for rotation on a relatively short pedicle. Iyer et al.

suggested that it is a reliable and suitable option for lower anterior neck defect [38] including for revision of tracheostomes.

3.3.1.4 Thoracoacrominal artery perforator flap (TAAP)

The thoracoacrominal artery perforator (TAAP) flap is a local alternative solution for reconstruction of complex circumferential hypopharyngeal defects when free tissue transfer is contraindicated or neck vessels are depleted [39]. It can be harvested as a chimeric flap including both muscle and skin components to cover defects in pharynx as well as skin.

3.3.2 Free tissue transfer options

Free flaps can serve to

a. reinforce a primary closure (particularly in the post-radiation salvage setting),

b. as a patch or interposition for lost circumference or

c. as a "tubed" reconstruction in cases where circumferential pharyngeal reconstruction is required.

The introduction of a free flap harvested from outside the irradiated field helps improve vascularity in the wound bed, may aid with healing, and decrease the risk of wound complications. Subsequently, including a free flap as an onlay graft may also help even in situations where primary closure of the pharynx is otherwise possible [25]. A meta-analysis on risk factors by Sayle and Grant concluded that a flap-reinforced closure is warranted in the salvage setting and would be of the most significant benefit where patients had undergone concurrent chemoradiotherapy [40]. Significant reduction of the PCF rate was demonstrated by Higgins et al. when the temporoparietal fascia was used an onlay flap [41]. Fung et al. introduced the term "pharyngeal interposition graft" (PIG), which consist of fascia-only free flaps to improve tissue vascularity in salvage laryngectomy [10]. Paleri et al. demonstrated that the incorporation of vascularised flaps, as either a patch repair or as a PIG, reduced the rate of pharyngocutaneous fistula by one-third [42].

Free tissue transfer options for pharyngeal reconstruction include.

3.3.2.1 Radial forearm free flap

The radial forearm free flap (RFFF) is easy to harvest, has a long pedicle with excellent vessel calibre, and is made up of a thin, pliable skin paddle of variable size and form that allow a great deal of latitude in pharyngeal reconstruction [43]. Its long pedicle provides an option for vascular anastomosis to be performed on the contralateral neck.

One of the major advantages of this is that its inherently thin and pliable skin paddle matches the thickness of the pharyngoesophageal wall [43]. If there is sufficient mucosa to close the pharynx primarily, the RFFF can be harvested without a skin paddle as a fascia-only flap to reinforce the pharyngeal suture line.

3.3.2.2 Anterolateral thigh free flap

The anterolateral thigh free flap (ALT) can be used as an onlay, a patch, or a tubed flap. It has more considerable vascular variability when compared to the RFFF. Its thickness also varies significantly depending on a patient's body habitus. The excess adipose tissue can be removed to within 2 cm of the perforating vessel to limit the flap thickness [44]. The ALT can be raised as a chimeric flap with muscle (usually vastus lateralis). The muscle can serve to provide coverage of the great vessels in the case of concurrent radical neck dissections, to fill in neck contour defects, or as a vascularised bed to facilitate skin grafting for the external neck. A distal or a second skin paddle can be brought out to external skin and utilised as a monitoring paddle [45].

The main favourable characteristics of the ALT flap include reliable anatomy, long vascular pedicle, low donor-site morbidity, feasibility as a chimeric flap, and the possibility of an in-OR 2-team approach [46]. The ALT flap can provide up to 40 cm of length for oesophageal reconstruction, especially when folded in a conical fashion [47]. The donor site is closed primarily and typically, the only lasting sequelae include a vertically oriented scar along the thigh and thigh numbness (**Figures 2** and **3**).

3.3.2.3 Gastro-omental free flap

The gastro-omental flap was first described by Baudet [48] for use in 1979. It is typically raised via laparotomy although it can be harvested laparoscopically [49]. The flap provides a tubed segment of the greater curve of the stomach which is nourished by the right gastroepiploic artery and vein, which also supply an apron of omentum. The advantage of the gastro-omental flap is its unique wound-healing properties provided by the rich omental source of fibroblasts and other progenitor cells. The omentum also serves as a malleable vascularised layer over the microvascular anastomoses and protects the great vessels from contamination by salivary egress [50]. Fibrous adhesions form within 3 hours of flap inset, leading to rapid ingrowth of fibroblasts and capillaries, which provide a nutrient-rich bed ideally suited to facilitate healing in contaminated or chemoirradiated wounds [51].

Unlike the body of the stomach, the gastric antrum is sparsely populated by gastric parietal cells,. This theoretically avoids acid-secretion from the transferred tissues (**Figures 4** and **5**) [50].

3.3.2.4 Jejunal free flap

The jejunal flap provides a hollow viscus which can replace a circumferential pharyngeal defect. It has a relatively shorter pedicle than the other free flaps herein

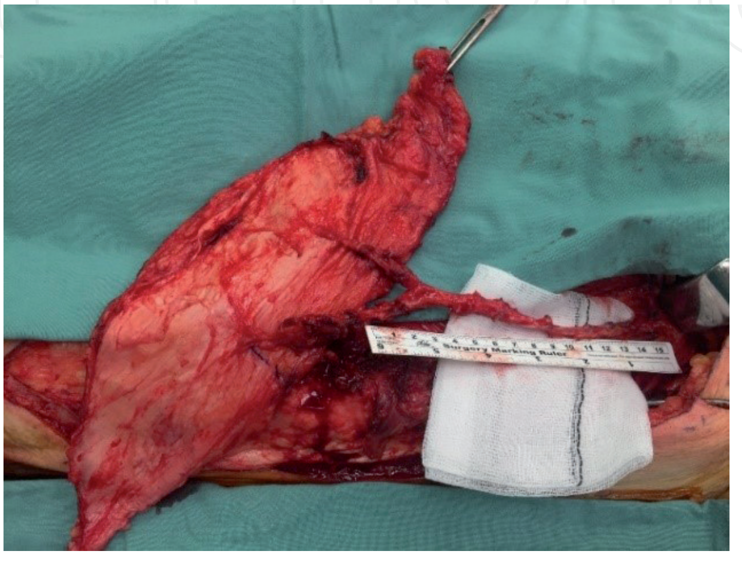

Figure 2.
ALT flap with pedicle.

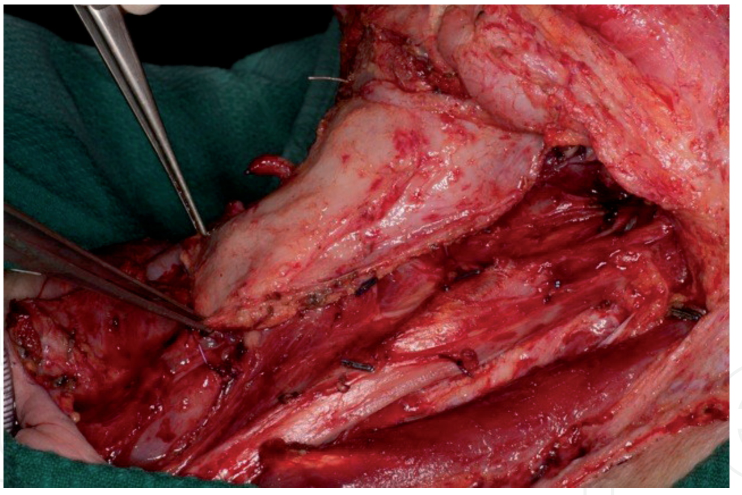

Figure 3.
Tubed ALT flap inset.

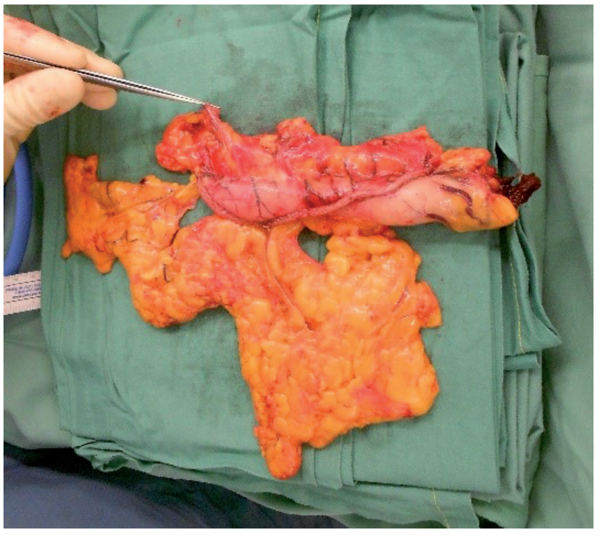

Figure 4.
Gastro-omental free flap.

described. A perioperative mortality rate was 3.8% in a series of 368 patients who had jejunal free flap for circumferential laryngopharyngectomy defects [52]. The potential morbidity of abdominal surgery such as postoperative ileus, wound infection, bowel obstruction, superior mesenteric syndrome, intra-abdominal bleeding, and delayed enteric feeding are significant complications in an already medically compromised population [53]. The jejunal flap is less tolerant of ischaemia and has a shorter pedicle than other flaps such as the ALT or gastro-omental flaps. The re-vascularised jejunal flap does not seem to withstand high doses radiotherapy [54]. Small bowel peristalsis generated by myenteric plexus does not seem to add any benefit to the pharyngeal phase of swallowing, as jejunal peristalsis does not coordinate with the rest of the upper digestive tract [25].

3.3.2.5 Temporoparietal fascial free flap

Temporoparietal fascial free flap (TPFF) is thin and pliable and can be used as a PIG to reinforce pharyngeal closures after salvage laryngectomy. Higgins et al. [41] demonstrated comparable wound outcomes to the pectoralis major myofascial flap without the associated shoulder and arm dysfunction. This flap has minimal donor site morbidity other than a 25% rate of local alopecia. The pedicle is short and with small calibre.

Figure 5.
Gastro-omental flap inset.

It is still possible to undertake a two-team approach if harvest commences after ipsilateral dissection is complete [41]. The use of the TPFF as an overlay technique is a useful adjunct for salvage laryngectomy cases where the defect is primarily closed. The reinforcement of the pharyngeal suture line has been shown to diminish the rate of PCF compared to historical controls with reduced donor-site morbidity and reduced length of hospitalisation (**Figure 6**).

3.3.2.6 Serratus anterior free flap

Khan et al. published the first series utilising the serratus anterior free flap (SAFF) as an onlay to reinforce primary closure [55]. Authors cite the ease of harvest, low donor site morbidity, and the pliability of the flap as significant advantages over other free flaps used for similar purposes.

The shapes and sizes of all flaps depends upon the shape and size of the defect the surgeon is repairing.

3.4 Other considerations

3.4.1 Salivary bypass tube

The use of a salivary bypass tube to prevent PCF also remains controversial. While some maintain that salivary bypass tubes help funnel saliva into the oesophagus while bypassing the anastomosis, other denounce them as propagators of fistulation. Hone et al. found that in patients where a salivary bypass tube was used, the fistula rate was 8.3% compared to 24.6% in the control group [56]. However, in their multivariate analysis, this difference was not borne out to be significant. Perhaps the benefit of salivary bypass tubes in the circumferential reconstructive setting includes splinting of an otherwise highly collapsable neopharynx.

3.4.2 Tracheo-oesophageal puncture

Elective trachea-oesophageal puncture results in a fistula that allows for the use of a device for producing speech without reflux of digestive tract secretions into the trachea. The timing of tracheo-oesophageal puncture (TEP) placement is critical in the setting of salvage laryngectomy. Emerick et al. showed in salvage laryngectomy patients that fluency was 62 days earlier with the primary TEP group. However, the

Figure 6.
Temporoparietal flap.

rate of PCF was also significantly higher in the primary TEP group (50%) versus in the secondary TEP group (0%) [57].

Our preference is to delay TEP in the setting of pharyngolaryngectomy until after discharge. We have found that the posterior wall of the trachea is prone to unpredictable and inadvertent dilatation which may result in a fistula that is too large and can make placement of a speaking device difficult.

4. Post-op considerations

4.1 Postoperative monitoring

Postoperative free flap monitoring protocols are highly variable among different institutions. A systematic review by Dort et al. [58] suggested the need for intensive monitoring in the first 24 hours as most evidence suggests that vascular complications will occur within the first 24 hours in most patients [59]. The method of monitoring should include clinical examination by experienced staff and adjunct measures, such as the use of ultrasound doppler and needle prick. As free tissue transfers are employed to salvage pharyngeal defects, the surrounding recipient vessels are frequently compromised, especially in the neck region. Our experiences indicate that the rate of free flap complications is much higher, and that it may be worsened by the post-operative catabolic state and any underlying comorbid diseases. Preoperative preparations are critical for these cases.

Postoperative nutritional support in the form of nasogastric (NG) tube feeding is common for patients undergoing major head and neck surgery. In the event of a laryngopharyngectomy, the NG tube may be placed via the tracheostome for later replacement with a trachea-oesophageal fistula (TOF) for voice rehabilitation. Feeding gastrostomy or jejunostomy tube insertion needs to be considered during the preoperative planning phase when prolonged nutritional support is expected [60].

4.2 General care of the complex head and neck reconstruction patient

4.2.1 Antimicrobials

Clean-contaminated head and neck oncologic cases have significantly higher perioperative wound infection rates compared to clean cases [61]. Antibiotics given one to two hours preoperatively are shown to reduce wound infection rate [62]. However, a longer duration of post-operative antibiotics (i.e. up to 5 days) has not shown increased benefit in either wound infection or pneumonia [63]. Upper aerodigestive tract decontamination also has not demonstrated significant benefit [64]. A sensible approach is to provide perioperative antibiotics for at least 48 hours postoperatively, and up to 5 days in the salvage setting.

4.2.2 Thyroid function

Thyroid function is reduced in most cases due to either thyroidectomy or radiation-induced thyroid injury. The predominant morphological changes consist of atrophy, chronic inflammation with lymphocytic infiltration, vascular fibrosis, and follicular hyperplasia [65]. Apart from itsthe direct effects on sympathetic activities, thyroid function has a crucial role in wound healing. It is therefore imperative that thyroid function is checked in salvage setting even if the patient has a residual thyroid gland.

4.2.3 Nutrition

Although head and neck cancer-specific enhanced recovery after surgery (ERAS) protocols are yet to be defined, the recommendations may be extrapolated from those of other surgical oncology populations. ERAS protocols include reduced fasting time, avoidance of dehydration, and preoperative carbohydrate loading [66]. The benefit of preoperative nutritional management is augmented by postoperative nutritional formulae, including immune-supportive “immunonutrition.” Systematic reviews suggest a positive association between reduced length of hospital stay and postoperative administration of immunonutrition support [67]. Clinical studies explicitly targeting patients with pharyngeal reconstruction are warranted.

4.2.4 Cardiorespiratory rehab (and prehab)

Respiratory complications after major head and neck reconstruction may jeopardise postoperative recovery. Increased sputum load will delay the decannulation of tracheostomy and increase the overall length of stay [68]. Currently, there is no specific data available, but the benefit of respiratory physiotherapy is shown to have a clear benefit in general surgery postoperative setting [69]. Furthermore, improved recall has been demonstrated in a randomised study in head and neck patients who received preoperative education [70]. Introduction of breathing exercises as part of preoperative education would be beneficial.

4.3 Wound issues

4.3.1 Pharyngocutaenous fistula

Previous radiotherapy, previous chemotherapy, advanced primary tumours, concurrent neck dissection, and hypothyroidism are among the identified risk factors for developing a PCF [71]. With primary closure, the rate of PCF approximates 30–40% in most case series [42]. It incurs a number of effects including prolonged hospital stay, more intensive nursing and wound care requirements, delays to oral intake, delays in voice restoration, additional surgical procedures needed to address the fistula, gastrostomy-tube insertion, as well as catastrophic complications such as carotid and jugular bleeding [25].

A large case series showed that those who had received previous chemoradiotherapies had significantly higher incidences of wound complications (45 vs. 25%) and PCF rate (32 vs. 12%) when compared to those undergoing surgery without any previous therapy [72]. Consequently, the RTOG-91-11 study reported a major wound complication rate of 60% and a PCF rate of 30% in patients who underwent salvage laryngectomy [73].

The dual paddle technique was found to be protective against PCF formation [74]. It is important to note that three-quarters of the patients with PCF were managed successfully with conservative management, which suggests that repeated surgical intervention may be ill-advised, especially when there are concerns of poor wound healing from previous radiotherapy [30].

Dirven et al. [75] reported an association between fistula incidence and the interval between radiotherapy and surgery. There was a distinct difference in the incidence rates in patients who underwent salvage surgery within 12 months of radiotherapy (48%) and more than 12 months after radiotherapy (0%).

4.3.2 Wound sepsis and negative pressure dressing

The resection and donor site wounds must be cared for in patients with pharyngeal reconstruction. A systematic review showed no one dressing to be superior in primarily closed wounds [76]. The evidence for vacuum-assisted closure (VAC) device for complex open cervical wounds demonstrated a potential benefit [77]. Higher wound complication rates in salvage surgery would necessitate a more frequent use of VAC dressing after dehiscence and wound debridement.

4.3.3 Carotid blowout

Carotid blowout refers to the rupture of the carotid artery associated with neck surgery or radiation. It is uncommon but rapidly fatal. Radiotherapy results in a significantly higher rate of wound breakdown, PCF, and infection. Stripping of the carotid sheath, bacterial infection, and salivary contamination all contribute to desiccation and erosion of the carotid walls [78].

4.4 Donor site

Donor site morbidity is shown to be equivocal between free flap and pedicled flap reconstructions with no differences in the rate of infection, dehiscence, and haematoma [79]. The degree of functional impairment depends on the amount of tissue transferred as well as the patient's laterality.

4.5 Deglutition

Patients with the hypopharyngeal disease appear to have a significantly higher incidence of dysphagia [30]. This phenomenon is likely due to a loss of intrinsic propulsion and natural pharyngeal mucosa in the neopharynx [80]. Swallow studies are performed postoperatively between day 7 to day 10. Non-ionic water-soluble contrast (i.e. omnipaque 300) is used to reduce the risk of pneumonitis in case of aspiration [81]. Anastomotic integrity is assessed during fluoroscopy before initiation of oral intake.

4.6 Speech

There are two predominant types of alaryngeal speech for use after laryngectomy. Tracheo-oesophageal puncture (TEP) speech produces voice via passage of air from the lungs through a prosthetic valve positioned in the wall between the trachea and the pharynx or the upper oesophagus.. Oesophageal speech is achieved by passage of air from the mouth into the gastrointestinal track, which is oscillated through the oesophagus with simultaneous articulation of words. Voice produced by TEP is generally accepted as superior to oesophageal speech because TEP speech is lungpowered speech and, as such, may offer more durable and louder speech than oesophageal speech. Both primary and secondary punctures have shown success in achieving speech fluency [57, 82].

Speech quality was better with free flap than with PM flap reconstruction for oral cavity defects. However both free flap and PM flap reconstructions scored similarly on global quality of life, pain, swallowing, chewing, speech, activity, recreation, taste, saliva, anxiety, and on the composite score [79].

In gastric pull-up and jejunal flaps, while the puncture has been shown to be successful, the voice quality is often poor with a gurgling quality when compared to skin-lined flaps [29].

4.7 Role of specialised nursing postoperatively to coordinate recovery

The perioperative complexity of pharyngeal reconstruction extends well beyond the confines of the operating room. Specialised nursing staff are required for continuity of care, troubleshooting of early signs of deterioration, and the co-ordination of airway, chest, feeding, and rehabilitation priorities. Historically, roles of nursing staff centred on head and neck surgical patients [83] originated when specialist nursing team began managing increasing numbers of these patients on nonsurgical wards. These patient wards were described as "Critical Care Outreach teams" [84]. This ward specialises and focuses on the management of complex head and neck patients. The support provided by specialist nurses has contributed to decreases in complication rates, readmissions to the ICU, and the overall length of stay [85].

5. Conclusion

The pharyngeal defect poses challenges to reconstructive surgeons, especially when the patient has a hostile neck from previous surgery or radiotherapy. The reconstruction plan needs to be patient- and defect- oriented. The surgeon should carefully consider the available options to achieve most, if not all, of the reconstructive goals. Complex head and neck surgical patients also require a team of specialised professionals to assist in their journey of healing and recovery. Such a multidisciplinary team is a crucial part of reintegration of cancer survivors back to society.

Conflict of interest

Authors declare that there are no conflicts of interest.

Appendices and nomenclature

ALT	anterolateral thigh
ERAS	enhanced recovery after surgery
HPV	human papillomavirus
PCF	pharyngocutaneous fistula
PM	pectoralis major

RFFF	radial forearm free flap
SAFF	serratus anterior free flap
SCAIF	supraclavicular artery island flap
SCC	squamous cell carcinoma
TAA	thoracoacrominal artery perforator
TCA	transcervical artery
TEP	tracheoesophageal puncture
TOF	trachea-oesophageal fistula
TORS	transoral robotic surgery
TPFF	temporoparietal fascial free flap
VAC	vacuum-assisted closure

Author details

Takako Yabe[1] and Bruce Ashford[1,2]*

1 Illawarra Shoalhaven Local Health District, NSW, Australia

2 University of Wollongong, Australia

*Address all correspondence to: bruceash@uow.edu.au

References

[1] Lefebvre JL, Andry G, Chevalier D, Luboinski B, Collette L, Traissac L, et al. Laryngeal preservation with induction chemotherapy for hypopharyngeal squamous cell carcinoma: 10-year results of EORTC trial 24891. Annals of Oncology. 2012;**23**(10):2708-2714

[2] Caliceti U, Sgarzani R, Cipriani R, Cantore S, Contedini F, Pinto V, et al. Single stage reconstruction of complex head and neck defects involving the skin with a single ALT flap: A ten year review. Journal of Plastic, Reconstructive and Aesthetic Surgery. 2019;**22**:55-64

[3] Department of Veterans Affairs Laryngeal Cancer Study G, Wolf GT, Fisher SG, Hong WK, Hillman R, Spaulding M, et al. Induction chemotherapy plus radiation compared with surgery plus radiation in patients with advanced laryngeal cancer. The New England Journal of Medicine. 1991;**324**(24):1685-1690

[4] Forastiere AA, Zhang Q, Weber RS, Maor MH, Goepfert H, Pajak TF, et al. Long-term results of RTOG 91-11: A comparison of three nonsurgical treatment strategies to preserve the larynx in patients with locally advanced larynx cancer. Journal of Clinical Oncology. 2013;**31**(7):845-852

[5] Agrawal N, Goldenberg D. Primary and salvage total laryngectomy. Otolaryngologic Clinics of North America. 2008;**41**(4):771-780 vii

[6] Mäkitie AA, Irish J, Gullane PJ. Pharyngocutaneous fistula. Current Opinion in Otolaryngology & Head and Neck Surgery. 2003;**11**(2):78-84

[7] Disa JJ, Cordeiro PG. Reconstruction of the hypopharynx and cervical esophagus. Clinics in Plastic Surgery. 2001;**28**(2):349-360

[8] Sumer BD, Gastman BR, Nussenbaum B, Gao F, Haughey BH. Microvascular flap reconstruction of major pharyngeal resections with the intent of laryngeal preservation. Archives of Otolaryngology--Head & Neck Surgery. 2009;**135**(8):801-806

[9] Penel N, Fournier C, Lefebvre D, Roussel-Delvallez M, Sarini J, Kara A, et al. Previous chemotherapy as a predictor of wound infections in nonmajor head and neck surgery: Results of a prospective study. Head & Neck. 2004;**26**(6):513-517

[10] Fung K, Teknos TN, Vandenberg CD, Lyden TH, Bradford CR, Hogikyan ND, et al. Prevention of wound complications following salvage laryngectomy using free vascularized tissue. Head & Neck. 2007;**29**(5):425-430

[11] McGurk M, Goodger N. Head and neck cancer and its treatment: Historical review. British Journal of Oral and Maxillofacial Surgery. 2000;**38**(3):209-220

[12] Tamai S. History of microsurgery. Plastics and Reconstructive Surgery. 2009;**124**(6S):e282-e294

[13] Jiang N, Zhang LJ, Li LY, Zhao Y, Eisele DW. Risk factors for late dysphagia after (chemo)radiotherapy for head and neck cancer: A systematic methodological review. Head & Neck. 2016;**38**(5):792-800

[14] Mahalingam S, Srinivasan R, Spielmann P. Quality-of-life and functional outcomes following pharyngolaryngectomy: A systematic review of literature. Clinical Otolaryngology. 2016;**41**(1):25-43

[15] Takes RP, Strojan P, Silver CE, Bradley PJ, Haigentz M Jr, Wolf GT, et al. Current trends in initial management of

hypopharyngeal cancer: The declining use of open surgery. Head & Neck. 2012;**34**(2):270-281

[16] Disa JJ, Pusic AL, Mehrara BJ. Reconstruction of the hypopharynx with the free jejunum transfer. Journal of Surgical Oncology. 2006;**94**(6):466-470

[17] Ferahkose Z, Bedirli A, Kerem M, Azili C, Sozuer EM, Akin M. Comparison of free jejunal graft with gastric pull-up reconstruction after resection of hypopharyngeal and cervical esophageal carcinoma. Diseases of the Esophagus. 2008;**21**(4):340-345

[18] Nouraei SA, Mace AD, Middleton SE, Hudovsky A, Vaz F, Moss C, et al. A stratified analysis of the perioperative outcome of 17623 patients undergoing major head and neck cancer surgery in England over 10 years: Towards an informatics-based outcomes surveillance framework. Clinical Otolaryngology. 2017;**42**(1):11-28

[19] Patel SY, Meram AT, Kim DD. Soft tissue reconstruction for head and neck ablative defects. Oral and Maxillofacial Surgery Clinics of North America. 2019;**31**(1):39-68

[20] Couch ME. Laryngopharyngectomy with reconstruction. Otolaryngologic Clinics of North America. 2002;**35**(5):1097-1114

[21] Chan YW, Ng RW, Liu LH, Chung HP, Wei WI. Reconstruction of circumferential pharyngeal defects after tumour resection: Reference or preference. Journal of Plastic, Reconstructive and Aesthetic Surgery. 2011;**64**(8):1022-1028

[22] Chim H, Salgado CJ, Seselgyte R, Wei F-C, Mardini S, editors. Principles of Head and Neck Reconstruction: An Algorithm to Guide Flap Selection. Seminars in Plastic Surgery. Thieme Medical Publishers; 2010

[23] Kelly KE, Anthony JP, Singer M. Pharyngoesophageal reconstruction using the radial forearm fasciocutaneous free flap: Preliminary results. Otolaryngology–Head and Neck Surgery. 1994;**111**(1):16-24

[24] Novakovic D, Patel RS, Goldstein DP, Gullane PJ. Salvage of failed free flaps used in head and neck reconstruction. Head & Neck Oncology. 2009;**1**(1):33

[25] Yeh DH, Sahovaler A, Fung K. Reconstruction after salvage laryngectomy. Oral Oncology. 2017;**75**:22-27

[26] Hui Y, Wei WI, Yuen PW, Lam LK, Ho WK. Primary closure of pharyngeal remnant after total laryngectomy and partial pharyngectomy: How much residual mucosa is sufficient? The Laryngoscope. 1996;**106**(4):490-494

[27] Sassler AM, Esclamado RM, Wolf GT. Surgery after organ preservation therapy. Analysis of wound complications. Archives of Otolaryngology--Head & Neck Surgery. 1995;**121**(2):162-165

[28] Su CY, Chiang YC. The fabricated radial forearm flap in pharyngolaryngeal surgery: Saliva leakage and its prevention. British Journal of Plastic Surgery. 1995;**48**(4):212-217

[29] Cho BC, Kim M, Lee JH, Byun JS, Park JS, Baik BS. Pharyngoesophageal reconstruction with a tubed free radial forearm flap. Journal of Reconstructive Microsurgery. 1998;**14**(8):535-540

[30] Balasubramanian D, Subramaniam N, Rathod P, Murthy S, Sharma M, Mathew J, et al. Outcomes following pharyngeal reconstruction in total laryngectomy - institutional experience and review of literature. Indian Journal of Plastic Surgery. 2018;**51**(2):190-195

[31] Ariyan S. The pectoralis major myocutaneous flap. A versatile flap for reconstruction in the head and neck. Plastic and Reconstructive Surgery. 1979;**63**(1):73-81

[32] Patel UA, Moore BA, Wax M, Rosenthal E, Sweeny L, Militsakh ON, et al. Impact of pharyngeal closure technique on fistula after salvage laryngectomy. JAMA Otolaryngology-Head & Neck Surgery. 2013;**139**(11):1156-1162

[33] Burke MS, Kaplan SE, Kaplowitz LJ, Lotempio MM, Hicks WL Jr, Rigual NR, et al. Pectoralis major myocutaneous flap for reconstruction of circumferential pharyngeal defects. Annals of Plastic Surgery. 2013;**71**(6):649-651

[34] Deschler DG, Doherty ET, Reed CG, Singer MI. Quantitative and qualitative analysis of tracheoesophageal voice after pectoralis major flap reconstruction of the neopharynx. Otolaryngology–Head and Neck Surgery. 1998;**118**(6):771-776

[35] Emerick KS, Herr MA, Deschler DG. Supraclavicular flap reconstruction following total laryngectomy. The Laryngoscope. 2014;**124**(8):1777-1782

[36] Trautman J, Gore S, Potter M, Clark J, Hyam D, Tan NC, et al. Supraclavicular flap repair in the free flap era. ANZ Journal of Surgery. 2018;**88**(6):540-546

[37] Lamberty BGH. The supra-clavicular axial patterned flap. British Journal of Plastic Surgery. 1979;**32**(3):207-212

[38] Iyer NG, Clark JR, Ashford BG. Internal mammary artery perforator flap for head and neck reconstruction. ANZ Journal of Surgery. 2009;**79**(11):799-803

[39] Song D, Pafitanis G, Pont LEP, Yang P, Koshima I, Zhang Y, et al. Chimeric thoracoacromial artery perforator flap for one-staged reconstruction of complex pharyngoesophageal defects: A single unit experience. Head & Neck. 2018;**40**(2):302-311

[40] Sayles M, Grant DG. Preventing pharyngo-cutaneous fistula in total laryngectomy: A systematic review and meta-analysis. The Laryngoscope. 2014;**124**(5):1150-1163

[41] Higgins KM, Ashford B, Erovic BM, Yoo J, Enepekides DJ. Temporoparietal fascia free flap for pharyngeal coverage after salvage total laryngectomy. The Laryngoscope. 2012;**122**(3):523-527

[42] Paleri V, Drinnan M, Van Den Brekel MW, Hinni ML, Bradley PJ, Wolf GT, et al. Vascularized tissue to reduce fistula following salvage total laryngectomy: A systematic review. The Laryngoscope. 2014;**124**(8):1848-1853

[43] Azizzadeh B, Yafai S, Rawnsley JD, Abemayor E, Sercarz JA, Calcaterra TC, et al. Radial forearm free flap pharyngoesophageal reconstruction. The Laryngoscope. 2001;**111**(5):807-810

[44] Nojima K, Brown SA, Acikel C, Arbique G, Ozturk S, Chao J, et al. Defining vascular supply and territory of thinned perforator flaps: Part I. anterolateral thigh perforator flap. Plastic and Reconstructive Surgery. 2005;**116**(1):182-193

[45] Zelken JA, Kang CJ, Huang SF, Liao CT, Tsao CK. Refinements in flap design and inset for pharyngoesophageal reconstruction with free thigh flaps. Microsurgery. 2017;**37**(2):112-118

[46] Wong CH, Wei FC. Microsurgical free flap in head and neck reconstruction. Head & Neck. 2010;**32**(9):1236-1245

[47] Benazzo M, Occhini A, Fossati G, Caracciolo G. Reconstruction of intrathoracic oesophagus using tubular lateral thigh free flap. The Journal of Laryngology and Otology. 2000;**114**(7):551-553

[48] Baudet J. Reconstruction of the pharyngeal wall by free transfer of the greater omentum and stomach. International Journal of Microsurgery. 1979;**1**:53-59

[49] Craig SJ, Zhang A, Gardner TD, Clark JR, Ashford BG. Laparoscopic harvest of the gastro-omental free flap for reconstruction after total pharyngolaryngectomy: Operative technique. Head & Neck. 2017

[50] Patel RS, Gilbert RW. Utility of the gastro-omental free flap in head and neck reconstruction. Current Opinion in Otolaryngology & Head and Neck Surgery. 2009;**17**(4):258-262

[51] Moran WJ, Panje WR. The free greater omental flap for treatment of mandibular osteoradionecrosis. Archives of Otolaryngology--Head & Neck Surgery. 1987;**113**(4):425-427

[52] Perez-Smith D, Wagels M, Theile DR. Jejunal free flap reconstruction of the pharyngolaryngectomy defect: 368 consecutive cases. Journal of Plastic, Reconstructive and Aesthetic Surgery. 2013;**66**(1):9-15

[53] Bearelly S, Heaton CM, Seth R, Daniel KP. Laryngopharyngeal repair in salvage Laryngectomy. Current Otorhinolaryngology Reports. 2016;**4**(3):211-218

[54] van Brederode TD, Halmos GB, Stenekes MW. Functional outcome after one-stage flap reconstruction of the hypopharynx following tumor ablation. European Archives of Oto-Rhino-Laryngology. 2017;**274**(2):969-976

[55] Khan MN, Rodriguez LG, Pool CD, Laitman B, Hernandez C, Erovic BM, et al. The versatility of the serratus anterior free flap in head and neck reconstruction. The Laryngoscope. 2017;**127**(3):568-573

[56] Hone RWA, Rahman E, Wong G, Annan Y, Alexander V, Al-Lami A, et al. Do salivary bypass tubes lower the incidence of pharyngocutaneous fistula following total laryngectomy? A retrospective analysis of predictive factors using multivariate analysis. European Archives of Oto-Rhino-Laryngology. 2017;**274**(4):1983-1991

[57] Emerick KS, Tomycz L, Bradford CR, Lyden TH, Chepeha DB, Wolf GT, et al. Primary versus secondary tracheoesophageal puncture in salvage total laryngectomy following chemoradiation. Otolaryngology–Head and Neck Surgery. 2009;**140**(3):386-390

[58] Dort JC, Farwell DG, Findlay M, Huber GF, Kerr P, Shea-Budgell MA, et al. Optimal perioperative Care in Major Head and Neck Cancer Surgery with Free Flap Reconstruction: A consensus review and recommendations from the enhanced recovery after surgery society. JAMA Otolaryngology-Head & Neck Surgery. 2017;**143**(3):292-303

[59] Pattani KM, Byrne P, Boahene K, Richmon J. What makes a good flap go bad? A critical analysis of the literature of intraoperative factors related to free flap failure. The Laryngoscope. 2010;**120**(4):717-723

[60] Talwar B, Findlay M. When is the optimal time for placing a gastrostomy in patients undergoing treatment for head and neck cancer? Current Opinion in Supportive and Palliative Care. 2012;**6**(1):41-53

[61] Skitarelić N, Morović M, Manestar D. Antibiotic prophylaxis in clean-contaminated head and neck

oncological surgery. Journal of Cranio-Maxillofacial surgery. 2007;**35**(1):15-20

[62] Rodrigo JP, Alvarez JC, Gómez JR, Suárez C, Fernández JA, Martínez JA. Comparison of three prophylactic antibiotic regimens in clean-contaminated head and neck surgery. Head & neck. 1997;**19**(3):188-193

[63] Liu SA, Tung KC, Shiao JY, Chiu YT. Preliminary report of associated factors in wound infection after major head and neck neoplasm operations--does the duration of prophylactic antibiotic matter? The Journal of Laryngology & Otology. 2008;**122**(4):403-408

[64] Simons JP, Johnson JT, Yu VL, Vickers RM, Gooding WE, Myers EN, et al. The role of topical antibiotic prophylaxis in patients undergoing contaminated head and neck surgery with flap reconstruction. The Laryngoscope. 2001;**111**(2):329-335

[65] Galbo AML, Kuik DJ, Lips P, von Blomberg BME, Bloemena E, Leemans CR, et al. A prospective longitudinal study on endocrine dysfunction following treatment of laryngeal or hypopharyngeal carcinoma. Oral Oncology. 2013;**49**(9):950-955

[66] Mortensen K, Nilsson M, Slim K, Schäfer M, Mariette C, Braga M, et al. Consensus guidelines for enhanced recovery after gastrectomy: Enhanced recovery after surgery (ERAS®) society recommendations. British Journal of Surgery. 2014;**101**(10):1209-1229

[67] Drover JW, Dhaliwal R, Weitzel L, Wischmeyer PE, Ochoa JB, Heyland DK. Perioperative use of arginine-supplemented diets: A systematic review of the evidence. Journal of the American College of Surgeons. 2011;**212**(3):385-399, 399.e381

[68] Brookes JT, Seikaly H, Diamond C, Mechor B, Harris JR. Prospective randomized trial comparing the effect of early suturing of tracheostomy sites on postoperative patient swallowing and rehabilitation. Journal of Otolaryngology. 2006;**35**(2):77-82

[69] Thomas JA, McIntosh JM. Are incentive spirometry, intermittent positive pressure breathing, and deep breathing exercises effective in the prevention of postoperative pulmonary complications after upper abdominal surgery? A systematic overview and meta-analysis. Physical Therapy. 1994;**74**(1):3-10 discussion 10-16

[70] Chan Y, Irish JC, Wood SJ, Rotstein LE, Brown DH, Gullane PJ, et al. Patient education and informed consent in head and neck surgery. Archives of Otolaryngology--Head & Neck Surgery. 2002;**128**(11):1269-1274

[71] Dedivitis RA, Aires FT, Cernea CR, Brandão LG. Pharyngocutaneous fistula after total laryngectomy: Systematic review of risk factors. Head & Neck. 2015;**37**(11):1691-1697

[72] Ganly I, Patel S, Matsuo J, Singh B, Kraus D, Boyle J, et al. Postoperative complications of salvage total laryngectomy. Cancer. 2005;**103**(10):2073-2081

[73] Forastiere AA, Goepfert H, Maor M, Pajak TF, Weber R, Morrison W, et al. Concurrent chemotherapy and radiotherapy for organ preservation in advanced laryngeal cancer. The New England Journal of Medicine. 2003;**349**(22):2091-2098

[74] Sparks DS, Myers H, Grinsell D. Single-stage reconstruction of combined hypopharyngeal and anterior neck skin defects with the dual-paddle anterolateral thigh flap. European Journal of Plastic Surgery. 2018;**41**(3):299-306

[75] Dirven R, Swinson BD, Gao K, Clark JR. The assessment

of pharyngocutaneous fistula rate in patients treated primarily with definitive radiotherapy followed by salvage surgery of the larynx and hypopharynx. The Laryngoscope. 2009;**119**(9):1691-1695

[76] Dumville JC, Gray TA, Walter CJ, Sharp CA, Page T, Macefield R, et al. Dressings for the prevention of surgical site infection. Cochrane Database of Systematic Reviews. 2016;**12**

[77] Satteson ES, Crantford JC, Wood J, David LR. Outcomes of vacuum-assisted therapy in the treatment of head and neck wounds. The Journal of Craniofacial Surgery. 2015;**26**(7):e599-e602

[78] Suárez C, Fernández-Alvarez V, Hamoir M, Mendenhall WM, Strojan P, Quer M, et al. Carotid blowout syndrome: Modern trends in management. Cancer Management and Research. 2018;**10**:5617

[79] Gabrysz-Forget F, Tabet P, Rahal A, Bissada E, Christopoulos A, Ayad T. Free versus pedicled flaps for reconstruction of head and neck cancer defects: A systematic review. Journal of Otolaryngology - Head & Neck Surgery. 2019;**48**(1):13

[80] Walther EK, Herberhold C. Computerized manometry and deglutition after pharyngolaryngeal tumor resections. Laryngo- Rhino-Otologie. 1993;**72**(2):67-72

[81] Zhong J, Nejadhamzeeigilani H, Thomson E, Tolan D, Roe G, Kaye T, editors. Fluoroscopy at its Finest: Post-Operative Assessment after Laryngo-Pharyngeal and Upper Gastrointestinal Tract surgery2017. European Congress of Radiology; 2017

[82] Gitomer SA, Hutcheson KA, Christianson BL, Samuelson MB, Barringer DA, Roberts DB, et al. Influence of timing, radiation, and reconstruction on complications and speech outcomes with tracheoesophageal puncture. Head & Neck. 2016;**38**(12):1765-1771

[83] Russell C, Harkin H. The benefits of tracheostomy specialist nurses. Nursing Times. 2001;**97**(46):40

[84] Lewis T, Oliver G. Improving tracheostomy care for ward patients. Nursing Standard. 2005;**19**(19):33

[85] Sodhi K, Shrivastava A, Singla MK. Implications of dedicated tracheostomy care nurse program on outcomes. Journal of Anesthesia. 2014;**28**(3):374-380