REVIEW ARTICLE

Total Laryngectomy

[1]Arash Mohebati, [2]Jatin P Shah

[1]Senior Fellow in Head and Neck Surgery, Memorial Sloan Kettering Cancer Center, New York, USA

[2]Professor of Surgery, EW Strong Chair in Head and Neck Oncology, Chief, Head and Neck Service, Memorial Sloan Kettering Cancer Center, New York, USA

Correspondence: Jatin P Shah, Professor of Surgery, EW Strong Chair in Head and Neck Oncology, Chief, Head and Neck Service, Memorial Sloan Kettering Cancer Center, New York, NY 10065, USA, e-mail: shahj@mskcc.org

Abstract

Total laryngectomy since it was first performed more than a century ago has undergone numerous modifications with increasing attention to voice restoration. Function preservation has also been achieved by voice sparing surgical procedures, and organ preservation strategies with chemoradiotherapy for laryngeal carcinoma. However, total laryngectomy remains the standard of care for very advanced laryngeal cancers with cartilage destruction, and as a salvage procedure for failures to organ preservation therapies. In this article, we review the indications, complications and outcomes of total laryngectomy in the era of chemoradiotherapy.

Keywords: Laryngectomy, Salvage surgery, Laryngeal cancer, Complications of laryngectomy, Pharyngocutaneous fistula, Tracheal stoma, Squamous cell carcinoma of the head and neck.

HISTORY

Although history credits Patrick Watson for performing the first total laryngectomy (TL) in 1866, there are reports that this was a postmortem laryngectomy on a patient that died from a syphilitic larynx.[1] The first reported TL for a malignancy was performed by Bilroth in 1873 and was reported at the third congress of surgeons by his assistant Gussenbauer.[1-3] The early laryngectomies were fraught with complications like pneumonia, aspiration, sepsis and fistula formation that resulted in extremely poor outcomes with reported operative or early postoperative mortality of near 50%. Towards the end of the 19th century suturing the trachea to the skin was introduced by Solis-Cohen, and the principle of tracheal diversion with the primary reconstruction of the pharynx was added by Gluck and Soerensen.[4,5] The increasing attention to functional outcomes of laryngectomy, such as swallowing and speech resulted in continuous modification of the surgical procedure over time and the subsequent introduction of tracheo-esophageal puncture (TEP) in 1980 by Singer and Blom.[6] Over the course of the last century, with increasing emphasis on the concept of function preservation, multiple procedures of partial laryngectomy have been introduced and for these patients, who need TL, chemotherapy and radiation has become the standard of care. However, TL remains a viable option in the management of patients with laryngeal cancer.

Indications for Total Laryngectomy

The indications for TL have evolved over the last two decades with the introduction of organ preservation strategies. During the third quarter of last century, conservation surgery for laryngeal cancer, such as hemilaryngectomy, suppraglottic laryngectomy, supracricoid laryngectomy and many variations of near total laryngectomy were quite popular, thus the need for total laryngectomy as the sole operation for laryngeal cancer declined.[7,8] However, patients who were not suitable for partial laryngectomy had no alternative but TL. A fundamental shift in this treatment paradigm was introduced by the landmark study conducted by the Department of Veterans Affairs Laryngeal Cancer Study Group in 1991.[9] Subsequently, concurrent chemotherapy and radiation was shown to be superior to induction chemotherapy followed by radiation or radiation alone for laryngeal preservation and locoregional control with similar overall survival among the groups.[10] The oncologic and functional success of these treatment modalities dramatically decreased the indications for total laryngectomy.

Currently, primary total laryngectomy for laryngeal squamous cell carcinoma (SCC) is offered to patients, who are not amenable to organ preservation techniques, such as concurrent chemotherapy and radiation, radiation alone or partial laryngectomy operations. This includes large tumors invading through the cartilage, extralaryngeal tissue or the

base of the tongue (T4a). Patients with tumors of certain histopathologic subtype that are not curable by radiotherapy such as adenocarcinoma, soft tissue sarcoma, chondrosarcoma, minor salivary gland tumors, spindle cell carcinoma, melanoma and large cell neuroendocrine tumors of the larynx may be treated with TL.[11,12] Other indications for TL include large thyroid cancers with laryngeal involvement, large tumors of the oropharynx with extension into the larynx and hypopharyngeal cancers.

Salvage total laryngectomy is indicated for patients, who have failed laryngeal preservation options, such as chemoradiotherapy, radiation alone or partial laryngeal operations. Additionally TL is indicated for sequelae of organ preservation techniques, such as dysfunctional larynx with life threatening aspiration or chondroradionecrosis unresponsive to medical therapy.

Surgical Technique

Total laryngectomy has been performed using a variety of incisions described in the literature. In the earlier part of the past century, a single vertical midline incision extending from the hyoid up to the superior border of the permanent tracheostomy was in practice. The rationale to employ this incision was direct access to the larynx and minimal mobilization of the soft tissues of the lateral neck. However, this incision did not offer an opportunity to combine laryngectomy with a neck dissection. In addition, if there was a wound breakdown and fistula formation then the fistula was directly draining into the tracheostomy. For those reasons, the midline vertical incision became obsolete.

In many centers, a U-shaped incision with a cervical apron flap is employed for total laryngectomy. Although this incision provides access and exposure for doing simultaneous neck dissection if indicated, it has many disadvantages. The superiorly-based skin flap does not have adequate vascularity at the lower end of the flap, which will form the superior border of the permanent tracheostomy. Wound breakdown at that site is quite common. In addition, if the patient develops a pharyngocutaneous fistula then the fistulous drainage directly leads to the tracheostomy making its management difficult. Therefore, we do not recommend a U-shaped incision for total laryngectomy.

Considering all the factors involved in ablative surgery as well as reconstructive surgery, we currently recommend the use of a single transverse incision extending from the posterior border of the sternocleidomastoid muscle on one side of the neck to that on the other side of the neck along a midcervical skin crease overlying the thyroid cartilage. The incision provides exposure for both sides of the neck for neck dissection, if necessary, and offers sufficient exposure of the central compartment of the neck from the upper border of the hyoid bone cephalad to the tracheostomy caudad. A separate circular incision is made in the suprasternal notch for creation of a permanent tracheostomy. This incision offers all the advantages of avoiding a vertical incision in the neck and keeps the tracheostomy separate and clear from the pharyngocutaneous suture line such that in the event of a pharyngocutaneous fistula, the tracheostomy remains intact. The transverse incision should be placed in such a way that there is at least a 2 to 3 cm distance between the upper end of the tracheostomy and the surgical incision. The reader is referred to many excellent textbooks of operative techniques in head and neck surgery for specific details of the operative steps for total laryngectomy.

Complications

Complications after total laryngectomy have profound impact on patient morbidity and the quality of life ultimately resulting in prolonged hospital stay, need for additional operations and increased medical costs. The early complications of TL include bleeding, hematoma, infection, wound complications, chyle leak, and pharyngocutaneous fistula. In a retrospective review of 471 patients, who underwent total laryngectomy without any prior treatment, the incidence of postoperative mortality was 0.6% with overall complication rate of 30.7% with 29.2% major and 6.5% minor complications.[13] The postoperative medical complications of TL should be considered since a large number of patients undergoing TL have multiple co-morbidities. In a chart review of 384 postlaryngectomy patients, serious nonfatal medical complications occurred in 6.3% of patients and 21.6% of which were pulmonary complications.[14] Preoperative history of stroke, significant cardiac disease, diabetes mellitus, and COPD were associated with serious postoperative medical complications. Additionally, the use of neoadjuvant therapy may increase the operative morbidity in these patients.[15]

The most common complication of total laryngectomy is pharyngocutaneous fistula (PCF) resulting in prolongation of hospital stay and delay in initiation of adjuvant therapy. PCF usually becomes evident between 4th to 10th days after laryngectomy.[16,17] The reported incidence of pharyngo-

cutaneous (PCF) fistula in literature varies from 2% to 35%.[13,18] In one retrospective review of 293 patients undergoing total laryngectomy, the incidence of PCF was reported to be 10.9%. Preoperative RT and the presence of concomitant chronic disease, such as diabetes and liver disease were associated with a statistically significant increase in the rate of PCF.[18,19] However, the role of preoperative RT in increasing PCF rate has been disputed by others. In one study, the fistula rate was increased only in patients, who underwent laryngectomy within three month of completing radiation therapy.[17]

In a multicenter prospective trial (RTOG 91-11) aimed to identify outcomes of salvage total laryngectomy following organ preservation therapy, the overall incidence of major and minor complications was 58%, 59%, and 52% for induction chemotherapy plus RT, concomitant chemo-radiotherapy and RT alone respectively.[20] Systemic complications included myocardial infarction leading to death, nonfatal cardiovascular events, and cerebrovascular accident. Wound complications included cellulitis, skin dehiscence, flap failure, pharyngocutaneous fistula, and hemorrhage. Pharyngocutaneous fistula occurred in 25%, 30% and 15% of induction chemotherapy plus RT, concomitant chemoradiotherapy and RT alone, respectively.

The rate of complications of salvage surgery following concurrent chemoradiotherapy (CCRT) or radiotherapy (RT) is reported to be higher than primary TL. In a retrospective study, complication rate in 86 patients undergoing salvage total laryngectomy was reviewed. The patients were divided into three groups: group one without prior RT or CCRT, group two with prior RT and group three with previous CCRT. There was an increased risk of major wound complications in group III compared to group I (29.4% *vs* 11.4%, $P = 0.078$), and a higher rate of PCF in group III compared to I (20.6% *vs* 5.7%, $P = 0.084$), but they did not reach statistical significance.[15] In addition, there was a higher rate of pharyngeal reconstruction in group III, while none of the patients in group I required additional reconstructive surgery. In another study, postoperative complications following primary total laryngectomy (PTL) and salvage total laryngectomy (STL) in patients after RT or chemoradiotherapy (CRT) were compared. The overall mortality rate was 0.5% with 40% of all patients developing a postoperative complication after total laryngectomy. Local complications were the most frequent complications and occurred in 28% of patients. PCF occurred in 17%, and a greater number of patients had local wound (45% *vs* 25%, $P = 0.02$) and fistula complications (32% *vs* 12%, $P = 0.012$) in the STL-CRT group compared with the primary laryngectomy group.[21] In this study, multivariate analysis showed that primary CRT was an independent predictor of local complications and pharyngocutaneous fistula formation.

The late complications of TL include stomal stenosis, pharyngoesophageal stenosis and hypothyroidism. In one reported study, the rate of post STL hypothyroidism was noted to be 17.5%.[22] Additional long-term effects of TL include pulmonary functional changes, psychiatric disorders, hyposmia, esophageal dysmotility and socioeconomic consequences. To study functional changes after total laryngectomy, a structured interview with 63 patients, who underwent laryngectomy was performed. Hyposmia was reported by 52% of the patients, while 15% experienced dysgeusia. A significant correlation was found between hyposmia and dysgeusia.[23] In patients undergoing TL, hypopharyngeal stenosis was noted to be more common when partial pharyngectomy was required and in patients with higher N-stage or recurrent disease.[24] In one study, 20% of the post TL patients required treatment of hypopharyngeal stenosis.[25]

Postlaryngectomy Rehabilitation

Total laryngectomy results in a variety of functional changes of which the most debilitating is loss of verbal communication followed by swallowing problems. Dysphagia is present in a large number of patients after total laryngectomy. The incidence of dysphagia after total laryngectomy is reported from 10 to 60%.[26,27] Many potential causes are associated with swallowing dysfunction, such as altered swallowing dynamics of neopharynx, stricture, gastroesophageal reflux, pharyngocutaneous fistula, anterior pharyngeal pouches, recurrent disease, TEP, tongue base resection and post RT changes, such as xerostomia and submucosal fibrosis.[27-29] In a retrospective review of 55 postlaryngectomy patients, 98% had swallowing impairment at discharge with inability to manage normal diet, and 3 year post discharge, only 58% were able to manage a normal diet.[30] Early oral feeding post-laryngectomy may play a factor in the rehabilitation of these patients. In a study of early oral feeding within 48 hours of surgery compared to the traditional 7 to 10 days post-operatively, the rate of PCF fared favorably in the early feeding group (3.6% *vs* 11%, respectively). Pharyngeal

stricture that required dilation occurred in three of the patients in the study group and two in the control group (5.5% *vs* 11%, respectively). The length of hospital stay was significantly shortened from 12 to 7 days.[31] Early initiation of oral feeding seems to be safe in post-laryngectomy patients without an increase in the rate of PCF. If dysphagia is present, further investigation by modified barium swallow test or manofluorography may facilitate diagnosis of the cause of dysphagia.[28]

The principal disability following TL is aphonia and permanent tracheostomy. Effective restoration of voice and speech is essential in improving the quality of life and enabling the patient to return to normal life activities and reduce the psychosocial and economic consequences of TL. Strategies for postlaryngectomy voice rehabilitation may be classified into three principal types of alaryngeal voice: esophageal, artificial larynx and surgically facilitated voice. The choice of speech rehabilitation should be individualized based on patient preferences and comorbidities. There have been multiple variations and modifications of the methods of postlaryngectomy voice rehabilitation. However, tracheoesophageal puncture followed by placement of an implantable valved prosthesis appears to be the most widely used solution for postlaryngectomy voice rehabilitation since its introduction by Singer and Blom in 1980.[5] Although the creation of tracheoesophageal puncture is technically simple at the time of TL, it is not without complications. In a review of 104 patients, who underwent TEP after TL, the complication rate of 25% was reported. These complications included migration and progressive enlargement of the puncture, persistent or recurring infection of the fistula site, aspiration pneumonia, aspiration of the prosthesis, vertebral osteomyelitis, and tracheal stomal and esophageal stenosis.[32] In a study comparing primary to secondary TEP in 30 patients undergoing this procedure, PCF occurred in 50% of the patients undergoing primary TEP *vs* 0% in patients undergoing secondary TEP. However, the patients undergoing primary TEP achieved fluent speech at a median of 63 days *vs* 125 days for secondary TEP.[33] In a prospective clinical study in a tertiary referral center, 71 post TL patients had TEP, of which 87% of patients underwent primary and 13%, secondary TEP. The overall success rate of TEP was 94%, with 97% for primary and 78% (P = 0.07) for secondary TEP. After 2 years, the success rate was 96% for primary and 75% for secondary (P = 0.07) TEP. The use of RT and patient age had no influence on the success of VP use for primary and secondary TEP.[34] There is evidence in the literature that complication rate of TEP varies depending on the primary mode of therapy in treatment of patients, who require TL. In a study to evaluate the complications of TEP in primary versus salvage surgery 187 patients were included. The incidence of leakage around the prosthesis, prosthesis dislodgement, and size changes 6 months or longer after laryngectomy were significantly higher for patients, who required STL after CRT or RT compared to primary TL.[35]

Management of Stoma

Physiologic consequence of permanent tracheal stoma after TL results in frequent involuntary coughing increased sputum production requiring repeated daily forced expectoration to clean the airway. Increased granulation tissue formation in trachea and tracheal stoma is another consequence of total laryngectomy. In a study to evaluate the cause of tracheal hypergranulation in 344 post-laryngectomy patients, duration of cannulation and age significantly influenced hypergranulation in these patients. It is recommended to keep the duration of cannulation as short as possible but considering underlying neurologic deficits.[36] Humidified air also may play a role in reduction of crusting and dryness of the trachea and assist in rehabilitation of postlaryngectomy patients. In a prospective multi-institutional study, role of heat and moisture exchanger (HME) in decreasing the respiratory symptoms following total laryngectomy was evaluated. A statistically significant improvement over time (between 3 and 6 months) was found in forced expectoration, stoma cleaning, perceived voice quality and in feelings of anxiety and depression in patients, who used HME.[37]

Stenosis of tracheal stoma after total laryngectomy is a distressing complication. A small stoma predisposes to drying, crusting, and inability to clear secretions, and the stenotic stoma interferes with TEP speech and ultimately results in respiratory compromise especially in patients with underlying pulmonary disease. Inadequate tracheostoma requires the patient to wear a laryngectomy tube or button to maintain an adequate airway. These tubes require constant care to maintain hygiene and prevent crust formation. Crusting causes irritation and leads to coughing as well as a bad smell. The reported incidence of tracheostomal stenosis ranges from 4 to 42% after laryngectomy.[38-41] It has been suggested that inadequate stoma size at initial surgery,

infection at the site of the stoma, fistula, steroid use, neck dissection, pectoralis major myocutaneous flap usage, primary tracheoesophageal puncture, and radiotherapy are predisposing risk factors for postoperative tracheostomal stenosis.[41,42] In a retrospective review of 207 patients undergoing TL, female gender and tracheostomal infection were independent predictors of stenosis on multivariate analysis.[41] In a study of 29 patients with postlaryngectomy stomal stenosis, multivariate analysis failed to show radiotherapy, chemotherapy, steroid use, fistula, stoma site, neck dissection or infection as a predisposing factor of tracheostomal stenosis.[39] The authors concluded that the most important factor in preventing tracheostomal stenosis is attention to detail and meticulous surgical technique while creating the stoma. Management of stomal stenosis ranges from mechanical dilations and stenting to surgical revision of the stoma.

Recurrence

Recurrence following TL for carcinoma of the larynx usually occurs at the stoma or in the neck. In a retrospective review of 80 cancer recurrences in 259 patients, who underwent TL, 35% recurred in the neck with 12.5% tracheostomal recurrence.[22] Distant metastasis occurred most commonly in the lungs in 13% of the patients. The mean interval between surgery and detection of recurrence was 11.6 months with 90% of all recurrences diagnosed within the first two years of follow-up.[22]

The incidence of parastomal recurrence after TL is reported in the literature from 2 to 15%, and it carries a dismal prognosis.[43-45] Most stomal recurrences are diagnosed within two years after total laryngectomy.[46] The reported risk factors for parastomal recurrence include preoperative tracheostomy, subglottic involvement, advanced tumor stage, paratracheal nodal metastasis and inadequate surgical margin.[43,44,47,48] In review of 444 post-laryngectomy patients, 3.4% developed parastomal recurrence. Tumor involvement of the subglottis was the single most important variable in parastomal recurrence.[49] Mean length of survival for the patients with parastomal recurrence in this study was 8.9 months. In a retrospective review of 141 patients, who underwent TL and paratracheal lymph node (PTLN) dissection, survival was significantly reduced in patients with PTLN involvement. PTLN metastases was identified in one-third of the patients of whom 4.4% developed peristomal recurrence. For patients without PTLN or regional LN involvement, OS was 87%, whereas none of the patients with PTLN metastasis survived beyond 42 months.[50] These authors recommended elective PTLN dissection in patients undergoing TL for carcinomas of larynx, hypopharynx and esophagus. In another review of 130 postlaryngectomy patients, the rate of parastomal recurrence was 10%. Stoma recurrence developed more often after salvage laryngectomy (18.4%) than primary laryngectomy and postoperative radiation (4.8%), and a correlation between larger primary T stage and recurrence was noted.[43] In a multi-institutional study of 57 patients with para stomal recurrence, the overall 2-year survival for operated patients was 16% with a 24% determinate survival.[51] The treatment options for stoma recurrence include surgery, radiation and chemotherapy.[51,52] Appropriate staging and adequate oncologic surgical resection are the basis for the surgical management of stomal recurrence. However, difficulty in obtaining adequate margins, correct estimation of the extent of disease, and the reconstruction of the pharynx, esophagus and maturation of the stoma makes surgical management of this disease challenging.

Outcomes/Survival

In a retrospective chart review of 142 patients, who underwent TL as primary treatment or salvage therapy for laryngopharyngeal primaries, the overall median survival of 23 months was achieved with a significantly better survival of 42 months for the laryngeal primaries. On univariate analysis, cancer site in the larynx, T3 stage, N0 to N1 stage, presence of no more than two comorbidities and absence of cardiovascular comorbidities at diagnosis were significant predictors of long-term survival. However, only T stage remained a significant predictor of survival on multivariate analysis.[53] In a study of 117 previously untreated laryngeal and hypopharyngeal cancers, disease-specific survival was significantly better among those with larynx cancer with a five-year survival rate of 67% for patients with cancer of the larynx and 37% for those with cancer of the hypopharynx.[54] The OS of patients undergoing STL after failure of conservative therapy at five-year is reported between 23 to 78%,[55,56] and the reported 10 year OS is between 37 to 48%.[57-59] In a retrospective review of 64 patients undergoing STL after RT, RT plus conservative surgery (CS) or CS, five and ten-year actuarial survival was 65.2% and 37.7% respectively, and no significant survival

difference was noted in the STL among the initial treatment arms.[58] In the prospective randomized multi-institutional study conducted by the RTOG, the morbidity and mortality of STL was evaluated. The indications for total laryngectomy included recurrence, progression, inadequate response, residual disease, necrosis and laryngeal dysfunction. The overall survival at 24 months for the STL patients was 69%, 71%, and 76% for induction chemotherapy plus RT, concomitant chemoradiotherapy and RT, respectively.[20] Distant failure with control above the clavicle occurred in 18%, 8%, and 20% of the above mentioned arms, respectively. In this study, patients undergoing STL had significantly worse survival than patients, who did not undergo salvage TL.

Postlaryngectomy Quality of Life

In a prospective study of quality of life in 10 patients prior to laryngectomy, at one year postlaryngectomy, and at two-year postlaryngectomy, the University of Washington Quality of Life (UW-QoL) questionnaire was administered. Postlaryngectomy QoL scores were not significantly different from prelaryngectomy scores and the functional limitations caused by a laryngectomy did not necessarily translate into a worse overall QoL.[60] In one study, a group of 34 patients undergoing laryngectomy, from the preoperative stage up to 6 months after surgery, completed the Short-Form Health Survey (SF-36) and a self developed quality of life. 63% of postlaryngectomy patients demonstrated significant and persistent communication problems up to 6 months postoperatively, and 75% reported swallowing problems 6 months after surgery that were not significantly different from preoperative evaluation (69%).[61] In a study to determine the significance of postlaryngectomy dysphagia on QoL, 110 patients completed the World Health Organisation Quality of Life-Bref (WHOQoL-Bref) and the UW-QoL questionnaires. There were no significant differences in QoL, as measured by the WHOQoL-Bref, between those laryngectomies with and without dysphagia. Laryngectomy patients with dysphagia, however had significantly impaired functioning and markedly reduced social participation and higher anxiety and depression as measured by the UW-QoL.[62] In another study, UW-QoL and short form-12 (SF-12) questionnaires were completed by 49 patients more than 2 years after laryngectomy. Patients identified speech, appearance, and activity as the most important problems after total laryngectomy. However, no correlation was seen between speech and overall QoL. The SF-12 showed no difference between normal subjects and laryngectomy subjects in the physical summary domain, but lower scores in physical function was observed in post-laryngectomy patients.[63] Although, many studies conclude that long-term QoL is not decreased after total laryngectomy when measured by the currently available and commonly used QoL instruments, inherent limitations of these questionnaires must be born in mind. Quality of life and functioning are discrete constructs that some of the current commonly employed questionnaires may not adequately and reliably capture and integrate.

REFERENCES

1. Weir NF, Theodore Billroth. The first laryngectomy for cancer. J Laryngol Otol 1973;87(12):1161-69.
2. Absolon KB, J Keshishian, First laryngectomy for cancer as performed by Theodor Billroth on December 31, 1873: A hundred anniversary. Rev Surg 1974;31(2):65-70.
3. Donegan WL. An early history of total laryngectomy. Surgery, 1965;57:902-05.
4. Agrawal N, Goldenberg D. Primary and salvage total laryngectomy. Otolaryngol Clin North Am 2008;41(4): 771-80.
5. Bien S, et al. History of voice rehabilitation following laryngectomy. Laryngoscope 2008;118(3):453-58.
6. Singer MI, Blom ED. An endoscopic technique for restoration of voice after laryngectomy. Ann Otol Rhinol Laryngol 1980;89(6 Pt 1):529-33.
7. Bocca E, Pignataro O, Oldini C. Supraglottic laryngectomy: 30 years of experience. Ann Otol Rhinol Laryngol 1983;92(1 Pt 1):14-18.
8. Ogura JH, Marks JE, Freeman RB. Results of conservation surgery for cancers of the supraglottis and pyriform sinus. Laryngoscope, 1980;90(4):591-600.
9. Induction chemotherapy plus radiation compared with surgery plus radiation in patients with advanced laryngeal cancer. The department of Veterans affairs laryngeal cancer study group. N Engl J Med 1991;324(24):1685-90.
10. Forastiere AA, et al. Concurrent chemotherapy and radiotherapy for organ preservation in advanced laryngeal cancer. N Engl J Med 2003;349(22):2091-98.
11. Thompson LD, Gannon FH. Chondrosarcoma of the larynx: A clinicopathologic study of 111 cases with a review of the literature. Am J Surg Pathol 2002;26(7):836-51.
12. Ganly I, et al. Malignant minor salivary gland tumors of the larynx. Arch Otolaryngol Head Neck Surg 2006;132(7): 767-70.
13. Herranz J, et al. Complications after total laryngectomy in nonradiated laryngeal and hypopharyngeal carcinomas. Otolaryngol Head Neck Surg 2000;122(6):892-98.
14. Arriaga MA, et al. Medical complications in total laryngectomy: Incidence and risk factors. Ann Otol Rhinol Laryngol 1990;99(8):611-15.

15. Furuta Y, et al. Surgical complications of salvage total laryngectomy following concurrent chemoradiotherapy. Int J Clin Oncol 2008;13(6):521-27.
16. Moses BL, Eisele DW, Jones B. Radiologic assessment of the early postoperative total-laryngectomy patient. Laryngoscope 1993;103(10):1157-60.
17. Hier M, Black MJ, Lafond G. Pharyngocutaneous fistulas after total laryngectomy: Incidence, etiology and outcome analysis. J Otolaryngol 1993;22(3):164-66.
18. Cavalot AL, et al. Pharyngocutaneous fistula as a complication of total laryngectomy: Review of the literature and analysis of case records. Otolaryngol Head Neck Surg 2000;123(5): 587-92.
19. McCombe AW, AS Jones. Radiotherapy and complications of laryngectomy. J Laryngol Otol 1993;107(2):130-32.
20. Weber RS, et al. Outcome of salvage total laryngectomy following organ preservation therapy: The radiation therapy oncology group trial 91-11. Arch Otolaryngol Head Neck Surg 2003;129(1):44-49.
21. Ganly I, et al. Postoperative complications of salvage total laryngectomy. Cancer 2005;103(10):2073-81.
22. Ritoe SC, et al. Cancer recurrence after total laryngectomy: Treatment options, survival, and complications. Head Neck 2006;28(5):383-88.
23. Ackerstaff AH, et al. Communication, functional disorders and lifestyle changes after total laryngectomy. Clin Otolaryngol Allied Sci 1994;19(4):295-300.
24. Kaplan JN, RA Dobie, CW Cummings. The incidence of hypopharyngeal stenosis after surgery for laryngeal cancer. Otolaryngol Head Neck Surg 1981;89(6):956-59.
25. McConnel FM, Duck SW, Hester TR. Hypopharyngeal stenosis. Laryngoscope, 1984;94(9):1162-64.
26. Balfe DM, et al. Barium examination of the esophagus after total laryngectomy. Radiology 1982;143(2):501-08.
27. Sullivan PA, Hartig GK. Dysphagia after total laryngectomy. Current opinion in otolaryngology and head and neck surgery 2001(9);7.
28. McConnel FM, Mendelsohn MS, Logemann JA. Examination of swallowing after total laryngectomy using manofluorography. Head Neck Surg 1986;9(1):3-12.
29. de Casso C, Slevin NJ, Homer JJ. The impact of radiotherapy on swallowing and speech in patients, who undergo total laryngectomy. Otolaryngol Head Neck Surg 2008;139(6): 792-97.
30. Ward EC, et al. Swallowing outcomes following laryngectomy and pharyngolaryngectomy. Arch Otolaryngol Head Neck Surg 2002;128(2):181-86.
31. Medina JE, Khafif A. Early oral feeding following total laryngectomy. Laryngoscope 2001;111(3):368-72.
32. Andrews JC, et al. Major complications following trach eoesophageal puncture for voice rehabilitation. Laryngoscope 1987;97(5):562-67.
33. Emerick KS, et al. Primary versus secondary tracheoesophageal puncture in salvage total laryngectomy following chemoradiation. Otolaryngol Head Neck Surg 2009;140(3): 386-90.
34. Chone CT, et al. Primary versus secondary tracheoesophageal puncture for speech rehabilitation in total laryngectomy: long-term results with indwelling voice prosthesis. Otolaryngol Head Neck Surg 2005;133(1):89-93.
35. Starmer HM, et al. Complications that affect postlaryngectomy voice restoration: Primary surgery vs salvage surgery. Arch Otolaryngol Head Neck Surg 2009;135(11):1165-69.
36. Ledl C, Mertl-Roetzer M. Tracheal and tracheostomal hypergranulation and related stenosis in long-term cannulated patients: Does the tracheostomy procedure make a difference? Ann Otol Rhinol Laryngol 2009;118(12):876-80.
37. Ackerstaff AH, Hilgers FJM, Aaronson NK, De Boer MF, Meeuwis CA, Knegt PPM, Spoelstra HAA, Van Zandwijk N, Balm AJM. Heat and moisture exchangers as a treatment option in the postoperative rehabilitation of laryngectomized patients. Clinical Otolaryngology and Allied Sciences, 1995;20(6):6.
38. Yonkers AJ, Mercurio GA (Jr). Tracheostomal stenosis following total laryngectomy. Otolaryngol Clin North Am 1983;16(2): 391-405.
39. Wax MK, Touma BJ, Ramadan HH. Tracheostomal stenosis after laryngectomy: Incidence and predisposing factors. Otolaryngol Head Neck Surg 1995;113(3):242-47.
40. Wax MK, Touma BJ, Ramadan HH. Management of tracheostomal stenosis. Laryngoscope 1999;109(9):1397-401.
41. Kuo M, et al. Tracheostomal stenosis after total laryngectomy: An analysis of predisposing clinical factors. Laryngoscope 1994;104(1 Pt 1):59-63.
42. Ho CM, et al. Tracheostomal stenosis after immediate tracheoesophageal puncture. Arch Otolaryngol Head Neck Surg 1991;117(6):662-65.
43. Zbaren P, Greiner R, Kengelbacher M. Stoma recurrence after laryngectomy: An analysis of risk factors. Otolaryngol Head Neck Surg 1996;114(4):569-75.
44. Imauchi Y, et al. Stomal recurrence after total laryngectomy for squamous cell carcinoma of the larynx. Otolaryngol Head Neck Surg 2002;126(1):63-66.
45. Leon X, et al. Prevention of stomal recurrence. Head Neck 1996;18(1):54-59.
46. Kowalski LP, et al. Stomal recurrence: Pathophysiology, treatment and prevention. Acta Otolaryngol 2003;123(3): 421-32.
47. Zhao H, et al. Stomal recurrence after total laryngectomy: A clinicopathological multivariate analysis. Am J Clin Oncol 2009;32(2):154-57.
48. Rockley TJ, et al. Postlaryngectomy stomal recurrence: Tumor implantation or paratracheal lymphatic metastasis? Clin Otolaryngol Allied Sci 1991;16(1):43-47.
49. Rubin J, Johnson JT, Myers EN. Stomal recurrence after laryngectomy: Interrelated risk factor study. Otolaryngol Head Neck Surg 1990;103[5 (Pt 1)]:805-12.
50. Weber RS, et al. Paratracheal lymph node dissection for carcinoma of the larynx, hypopharynx, and cervical esophagus. Otolaryngol Head Neck Surg 1993;108(1):11-17.
51. Gluckman JL, et al. Surgical salvage for stomal recurrence: A multi-institutional experience. Laryngoscope 1987;97(9): 1025-29.
52. Balm AJ, et al. Long-term results of concurrent polychemotherapy and radiotherapy in patients with stomal recurrence after total laryngectomy. Ann Otol Rhinol Laryngol 1986;95(6 Pt 1):572-75.
53. Woodard TD, Oplatek A, Petruzzelli GJ. Life after total laryngectomy: A measure of long-term survival, function, and quality of life. Arch Otolaryngol Head Neck Surg 2007;133(6):526-32.

54. Hall FT, et al. Clinical outcome following total laryngectomy for cancer. ANZ J Surg 2003;73(5):300-05.
55. Parsons JT, et al. Salvage surgery following radiation failure in squamous cell carcinoma of the supraglottic larynx. Int J Radiat Oncol Biol Phys 1995;32(3):605-09.
56. Virtaniemi JA, et al. Surgical management of irradiation failures in T1-T2 squamous cell carcinoma of the glottic larynx. Anticancer Res 2001;21(6A):4185-88.
57. Johansen LV, Grau C, Overgaard J. Glottic carcinoma: Patterns of failure and salvage treatment after curative radiotherapy in 861 consecutive patients. Radiother Oncol 2002;63(3):257-67.
58. Fowler BZ, et al. Factors influencing long-term survival following salvage total laryngectomy after initial radiotherapy or conservative surgery. Head Neck 2006;28(2):99-106.
59. Alcock CJ, et al. Salvage surgery following irradiation with different fractionation regimes in the treatment of carcinoma of the laryngo pharynx: Experience gained from a British Institute of Radiology Study. J Laryngol Otol 1992;106(2):147-53.
60. Deleyiannis FW, et al. Quality of life after laryngectomy: Are functional disabilities important? Head Neck 1999;21(4): 319-24.
61. Armstrong E, et al. An investigation into the quality of life of individuals after laryngectomy. Head Neck 2001;23(1):16-24.
62. Maclean J, Cotton S, Perry A. Dysphagia following a total laryngectomy: The effect on quality of life, functioning, and psychological well-being. Dysphagia 2009;24(3):314-21.
63. Vilaseca I, Chen AY, Backscheider AG. Long-term quality of life after total laryngectomy. Head Neck 2006;28(4):313-20.