

Total Laryngectomy – Past, Present, Future

Octavian CEACHIR^a; Razvan HAINAROȘIE^{a,b}; Viorel ZAINEA^{a,b}

^a“Carol Davila” University of Medicine and Pharmacy, Bucharest, Romania

^b“Prof. Dr. Dorin Hociota” Institute of Phonoaudiology and Functional ENT Surgery, Bucharest, Romania

ABSTRACT

In a period in which therapeutic approaches for malignant laryngeal tumors are focused on the principle of “organ preservation”, total laryngectomy is a well coded surgical procedure, addressed to the advanced laryngeal cancer which is not suitable for conservative techniques or in case of their failure.

The main objective of this work is to summarize the important events that have marked the evolution of this surgical technique to the current formula. Also this paper aims to identify, in our own casuistry, some elements of strategy and surgical technique required, in our opinion, for a successful therapeutic intervention.

The fundamental significance of the study is that we must learn from the past, perform our surgeries at contemporary standards and look to the future for new solutions and approaches of the advanced laryngeal malignancies.

Keywords: total laryngectomy, pharyngocutaneous fistula, vocal rehabilitation

BACKGROUND

Total laryngectomy is the surgical procedure in which the larynx is totally removed and the airway is interrupted, respiration being performed through a tracheal stoma resulting from bringing the trachea to the skin in the lower, anterior, cervical area. This provides a complete and permanent separation of the superior part of the airway from the inferior one, resulting in voice and smell loss.

This surgery is addressed, mainly, to advanced laryngeal malignancy or malignancy of adjacent anatomical structures, but can be also practiced in the case of post-traumatic laryngeal stenosis, insurmountable by other methods or cases of benign, extensive tumours with malignancy potential (recurrent laryngo-tracheal papillomatosis).

By correlating the findings from medical literature with our experience we will try to present, in the following passages, the surgical techniques used today for patients requiring to-

Address for correspondence:

Razvan Hainarosie, “Prof. Dr. D. Hociota” Institute of Phonoaudiology and Functional ENT Surgery, 21 Mihail Cioranu Street, 5th District, Bucharest, Romania.

E-mail: entheadnecksurg@gmail.com

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tal laryngectomy and the tips and tricks necessary for a successful intervention.

During the first half of the nineteenth century laryngology did not have the status of an independent specialty. Life expectancy being low, the patients didn't live enough to develop laryngeal malignancy, or if it occurred, it often passed unnoticed; the most important laryngeal pathology, at that time, was represented by the inflammatory diseases (diphtheria, tuberculosis, croup).

Some articles from the literature assign, erroneously, the performing of the first total laryngectomy to the British surgeon Patrick Watson, in 1866. The study of medical records from that period attests that he only performed a "in vivo" tracheotomy in a patient with syphilitic laryngitis, total laryngectomy being performed post-mortem for teaching and demonstration purposes (1). A few years later, in 1870, Czerny, one of Billroth's assistants from Vienna, conducted five experimental laryngectomies in dogs; the results were questionable, 80% of the dogs died, so the experiments were terminated (2).

In fact, the first total laryngectomy for a malignant tumour was performed by Billroth in Vienna on the 31st of December, 1873 (3). A month before this intervention, he practiced a median cricothyroidotomy and endolaryngeal excision of the tumour on the same patient. Massive tumour recurrence required total laryngectomy; the intervention was hampered by significant bleeding, intermittent awakening from anesthesia and cough. Although the post-operative course was complicated by a significant faringocutaneous fistula, the patient resumed oral nutrition. Later he was even mounted an artificial larynx, created by Gussenbauer. The patient survived for 7 months (4).

In 1875, Enrico Bottini from Turin conducted a total laryngectomy in a patient who survived for 10 years after surgery (5). In 1880 Gluck reported, in a retrospective study, that intraoperative and immediate postoperative mortality after total laryngectomy was 50%. In agreement with these results, in order to decrease early mortality, he proposed conducting the intervention in two stages: initial the separation of the trachea from the larynx followed, in the second stage, two weeks later, by total laryngectomy (6). Sorenson perfected, in 1890, a new total laryngectomy technique in one step, very similar to the current ones, the retrograde laryngectomy.

Morell Mackenzie was the one who called for rigorous analysis of biopsy fragments and placed the obtained results as a criterion for selection of the patients who needed total laryngectomy (7). The American surgeon George Washington Crile was the one who recognized the important role of the lymphatic system and distant tumoral metastasis and had a major influence in the implementation of radical neck dissection routine in the same intervention with the total laryngectomy (8). After multiple improvements in technique and instrumentation, Martin and Ogura have standardized total laryngectomy with neck dissection, around 1950 (9).

In the last decade the focus had increased more on the principle of organ preservation, multiple techniques of partial laryngectomy by both means, classical or endoscopic CO₂ LASER surgery, being introduced; however, for patients requiring total laryngectomy, the multimodal therapy – surgery associated with radiotherapy and chemotherapy became a standard. □

CONTENT

Indications and contraindications for total laryngectomy

The development of surgical techniques that allow preservation of the larynx, and the development of chemotherapy and radiotherapy, with proven oncological and functional efficiency in some cases, resulted in the restriction of total laryngectomy indications.

Indications: tumours occupying the entire endolarynx; bilateral tumours or extended to more than one laryngeal region that are not suitable for partial laryngectomy; cases in which a partial laryngectomy is attempted and intraoperative findings require conversion to total laryngectomy; recurrence after radiotherapy; tumour recurrence after partial interventions/perichondritids of the thyroid after partial laryngectomy; tumours invading adjacent organs (pharynx, oesophagus, thyroid); histopathological subtypes of tumours that have proven resistant to radiotherapy: soft tissue sarcomas, condrosarcomas, melanomas, adenocarcinomas, large cell neuroendocrine tumours, tumours of the minor salivary glands; severe laryngeal trauma that doesn't allow functional reconstruction of the organ; laryngeal stenosis insurmountable by other types of

surgery; non - oncological diseases predisposing to chronic aspiration of food, endangering the patient's life; chronic inflammatory disease accompanied by liquefaction necrosis; recurrent laryngeal papillomatosis with an increased risk of tracheal invasion (10-12).

Contraindications: the presence of incurable synchronous tumours, the presence of incurable distant metastases, severe systemic general disease or poor general condition, tumour invading the profound parts of the tongue, a tumour that exceeds the prevertebral fascia, a tumour or metastasis that encases the common or internal carotid artery (12,13).

Surgical techniques

I. The craniocaudal laryngeal resection

The skin incision used for total laryngectomy is the Gluck - Sorenson U-shaped incision. The starting point of the incision is located at the apex of the mastoid or lower, at the angle of the mandible, continued on the anterior border of the sternocleidomastoid muscle up to 1-2 cm above the upper edge of the sternal notch; it is continued symmetrically to the other side (12,13). If tracheotomy was performed before total laryngectomy, the tracheal stoma will be included in the incision. Other types of incisions described in the literature are: the vertical midline incision, from the body of the hyoid bone to the tracheal stoma that has a major disadvantage- it does not provide access for lymph node dissection; the transverse cervical incision from the posterior border of the SCM on one side to the one on the other side, at the level of the thyroid cartilage, completed with a circular one for the tracheotomy; the double transverse incision; the Y incision described by Crile (14). In our opinion the Gluck-Sorenson provides optimal access for dissection of the lymph node areas and total laryngectomy, avoiding a difficult three-point closure.

Because the musculocutaneous flap is subplatysmal, the vascularisation of the flap is not compromised; the anterior and external jugular veins should remain attached to the underlying tissues. The anterior cervical flap consists of skin, subcutaneous tissue and platysma muscle. It is dissected up to a point above the hyoid bone.

If the tracheotomy has not been performed in a previous intervention, it will be performed immediately after lifting the cervical musculo-

cutaneous flap. The strap muscles are dissected on the mid-line, the thyroid isthmus will be identified and cut between two clamps. A thick thread is used to ligate the thyroid lobes. The trachea is opened by a horizontal incision in a place chosen according to the tumoral extension in the subglottis or trachea (usually between the 2nd and 3rd tracheal ring), in a manner that respects the oncologic principles of resection.

The next step is represented by the dissection of the lymph nodes, according to each case, which should be radical neck dissection, a modified radical neck dissection or a selective neck dissection (13,15).

After the dissection of the lymph nodes the strap muscles are sectioned at the level of the hyoid bone and mobilized in the inferior part of the neck until the end of the intervention when they will be used to cover the neo-pharynx, in multiple layers. Prelaryngeal cervical muscles are dissected bilaterally from the thyroid cartilage and the perichondrium is left on the resection piece. If the extension of the tumour is anterior, through the thyroid cartilage, the strap muscles will be left on place and resected in block with the larynx, cricoid and the tracheal rings.

The superior laryngeal artery and vein are identified and ligated in the vicinity of the superior horn of the thyroid cartilage.

After the disinsertion of the muscles from the surface of the thyroid cartilage is done, the pharyngeal constrictor muscles are cut from the posterior edge of the cartilage. Exposure of these muscles is achieved by lateral traction of the larynx with a surgical hook. Fascia is then sectioned from the superior horn of the thyroid cartilage and the incision is continued around the circumference of the cartilage.

The inferior thyroid artery is identified and ligated at the level of the cricoid cartilage. The laryngeal dissection being complete, we can proceed to the dissection of the pyriform sinuses starting in the superior part of the larynx.

A thick thread is passed through the thyrohyoid membrane and the larynx is tractioned to the inferiorly in order to expose the hyoid bone. The suprahyoid, infrahyoid muscles and connective tissue are cut using a scalpel, a classic bipolar cautery or radiofrequency. This creates a tunnel under the hyoid bone through which another thick wire is passed. The pharynx is addressed at the level of the original position of the hyoid bone.

In order to access the endopharynx, a gap is created between the base of the tongue and the superior border of the epiglottis. The pharyngeal incision should be as small as possible for an easier reconstruction of the pharynx. This creates the approach for grasping and tractioning the epiglottis upward and providing an overview of the larynx from above. The incision line follows the aryepiglottic fold and is united with the contralateral, symmetric one, on the superior border of the cricoid cartilage. The larynx is pulled downwards, resulting in a good exposure of the pharyngeal mucosa and facilitating the placement of the first pharyngeal mucosa sutures. To avoid making tension sutures, the patient's head should be turned from extension to slight flexion (normal position of the patient in everyday life). Atraumatic, intestinal suture needles and slowly absorbable wires are used to perform a cranio-caudal suture of the pharyngeal mucosa. The suture can be performed in a continuous manner or with separate threads. If the mucosa is still under tension, the dissection of the cervical oesophagus can be made and it will result in a new degree of mobility of the mucosa and the consequent decrease of tension in the suture. Maximum attention should be paid to how the mucosal edges are brought together so that its external parts come into contact only with portions of the same kind. The ends of the suture, made with continuous thread, must have sufficient length so that they can be caught in a forceps and provide the tension required to achieve a second suture, overlying the original one. This is achieved with separate wires, taking care not to pierce the pharyngeal mucosa. The second suture must be performed with care because if it is too loose it can lead to pharyngocutaneous fistula and if it's too tight it can cause pharyngeal stenosis (16).

During or after completion of the pharyngeal suture the nasogastric feeding tube is inserted. This will allow feeding until the healing is complete and the oral nourishment is resumed. Tissue dissection is continued to the rear wall of the larynx and upper part of the trachea with mobilisation of all of these structures. The trachea is cut obliquely, in an obtuse angle, from the lower edge of the tracheostomy, and the larynx is removed together with the underlying section of the trachea. The lower portion of the trachea is anchored at the suprasternal skin using non absorbable thick wires.

The next step consists in suturing the pre-laryngeal muscles, previously dissected with separate, absorbable threads. The suction drainage is placed in the prepharyngeal region and anchored to the skin with a non-absorbable thread. The anterior cervical flap is lowered and anchored to the trachea. The skin is sutured with non-absorbable separate threads. Wound dressing, in the early days, will be compressive, a maneuver that prevents the occurrence of seroma and/or fistulas.

II. Laryngeal resection – retrograde technique (Figure 1)

It is preferred for tumours located in the glottis and supraglottic floor, with or without local extension, because it eliminates the risk of transtumoral laryngeal resection (12,13). The steps are similar to the above described technique: Gluck-Sorenson incision, dissection and

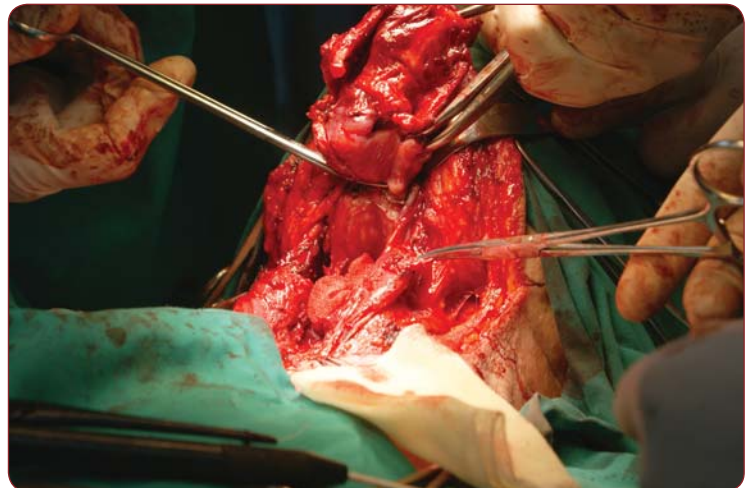


FIGURE 1. Retrograde laryngeal resection.

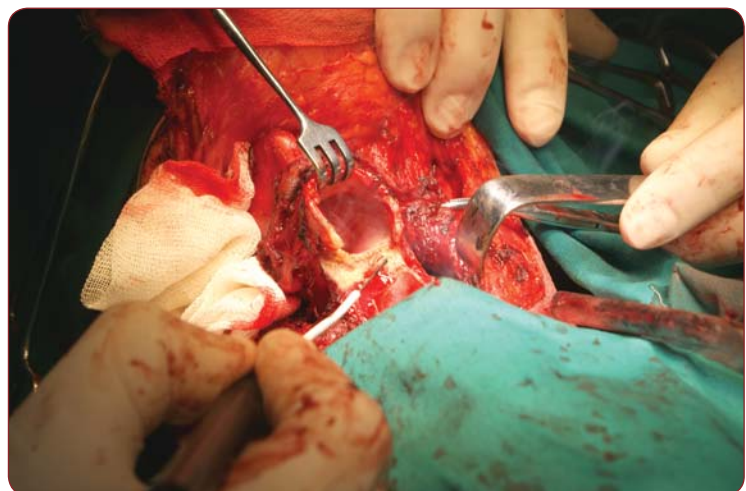


FIGURE 2. Finding the dissection plane between trachea and oesophagus.

preparation of the cervical flap, tracheotomy and neck dissection being performed in the same way. The differences from the technique presented above are: after lifting the cervical musculocutaneous flap, the hyoid bone is dissected and resected; the larynx is lifted, together with the superjacent tracheal rings, from the bottom up, by severing the trachea at the upper edge of the tracheostomy. A key point at this stage is finding the dissection plan between the thin posterior tracheal wall and the oesophagus (13) (Figure 2). The hypopharynx is accessed by an incision made just about 10 mm below the upper border of the cricoid lamina. The incision is then extended to the pyriform sinus situated contralateral to the tumour in order to limitate the loss of pharyngeal mucosa (Figure 3). Then the superior edge of the epiglottis should be identified, grasped and tractioned upward in a way that allows the inspection of the pharynx and an efficient tumoral resection, in block with the larynx, trachea and pharyngeal mucosa. The base of the tongue is cut and sutured with threads placed in an X shape.

Postoperative complications

Many of the candidates for total laryngectomy suffer from systemic diseases (diabetes, cardiovascular disease, chronic lung or liver disease) which have an impact on the development of postoperative complications that should be considered and anticipated for each case. Their incidence is correlated with the prolongation of hospitalization, need for secondary surgery, rising costs and a fall in the quality of life.

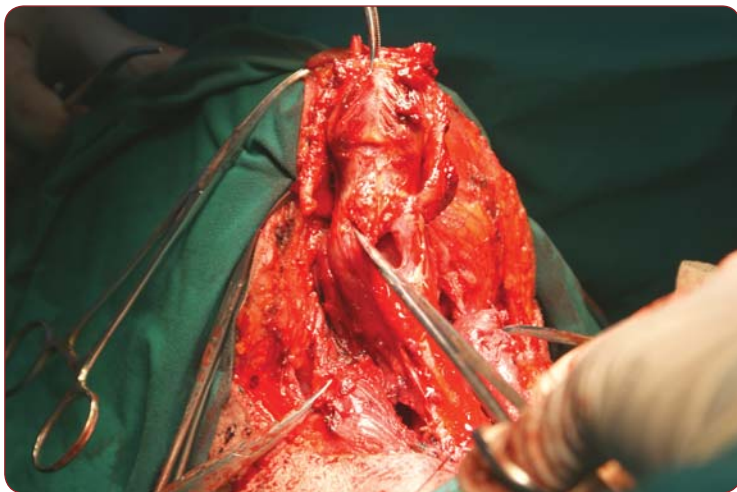


FIGURE 3. Entering the hypopharynx.

Early complications of total laryngectomy are: bleeding, lymphatic fistulas, hematoma, seroma, infection of the wound and/or adjacent tissue (cellulitis, wound dehiscence), pharyngotracheal or pharyngocutaneous fistulas (12,17). Pharyngocutaneous fistula (PCF) seems to be the most common complication among the ones presented in the anterior paragraph (18). Although pre-operative radiotherapy, chemotherapy and diabetes have been incriminated in the formation of PCF it seems that it can appear also in low compliant patients, due to early postoperative oral feeding (19,20).

Late complications include pharyngoesophageal stenosis, stoma stenosis and hypothyroidism (13,21).

Voice rehabilitation after total laryngectomy

Total laryngectomy has dramatic consequences on the patient, mainly through the loss of speech, an essential social function, loss of smell and the possibility of heating, humidifying and filtering the inhaled air and finally through the impact the tracheal stoma has over the patient or society.

Currently there are four main methods of voice rehabilitation for the laryngectomized patients: oesophageal voice, electrolarynx, the pneumatic artificial larynx and tracheoesophageal shunt prosthesis. Among these the vocal rehabilitation by voice prosthesis, after total laryngectomy, has represented the gold standard for the last two decades (22,23). □

COMMENTS

Key notes regarding cervical dissection during total laryngectomy

1. Exposure of subcutaneous tissue to the air from the operating room for a relatively long period of time (surgery lasting for about 4 hours), may increase the risk of tissue impairment and wound infection. It is advisable to protect the exposed areas by covering them with sterile compresses, soaked in saline, at certain times of the intervention.
2. Dissection of the muscles inserted on the hyoid must be performed carefully to obtain a small gap at this level, which will allow an easy T-shaped reconstruction, for better functional results and healing.
3. Upon entry into the pharynx, the surgeon must try to preserve as much pharyngeal

mucosa as possible, in order to achieve a tension-free suture which will prevent fistulas and will allow a rapid healing. The width of the remaining pharyngeal mucosa tranche must be at least 2.5 cm to allow its closure. This is a key requirement for avoiding pharyngeal stenosis, dysphagia and poor postoperative speech. In cases of large pyriform sinus tumours, of tumours extending to the cricopharyngeus, or involving the postcricoid area the remaining pharyngeal mucosa may be smaller than 2.5 cm. The pharynx may be reconstructed with pectoralis major, latissimus dorsi, or SCM flaps or with microvascular free tissue transfer flaps (15,24,25). Also a gastro-omental free flap can be used for one-stage reconstruction of complex hypopharyngeal defects after extensive ablative surgery (26).

5. A critical time is the suturing of the superior and lateral part of the pharyngeal mucosa to the base of the tongue, an area of election for producing fistulas due to increased pressure at this level during swallowing.
6. If the width of the free pharyngeal mucosa is insufficient for making a stress-free suture, a wet compress should be used to partially dissect its prevertebral portion, manoeuvre that will allow an optimal closure.
7. The tension in the pharyngeal sutures should be moderate (a factor of the utmost importance at this stage is the surgeon's experience) because too tight sutures may tear the mucosa or produce its necrosis, and those that are too loose, fistula or dehiscence may occur.
8. Intraoperative haemostasis must be achieved with care in order to avoid postoperative hematoma formation; those could lead to infection, tissue necrosis and adjacent fistulas.

9. The trachea should be anchored to the skin with thick threads disposed in a radial pattern; most of them should be passed through the suprasternal skin in such a way that the skin tension is transmitted to the tracheal rings and the stoma in opened wide, preventing stoma stenosis.
10. The diameter of the tracheal cannula should be within 3/4 of the diameter of the trachea in order to avoid the occurrence of pressure points that could lead to bleeding and other types of tracheal lesions. □

CONCLUSIONS

Total laryngectomy represents a well codified ablative surgical procedure.

It may also represent the first step (organ harvesting) in larynx transplantation, following different surgical anatomical models (27,28).

The association of total laryngectomy with the tracheoesophageal prosthesis represents a reasonable functional perspective and brings a note of optimism for the patient.

A number of tips and avoiding certain pitfalls in the course of performing total laryngectomy are of real benefit in the long-term success of this type of surgery.

Introduced in 1873, codified in 1950 and constantly refined to date, we believe that this type of surgery has passed the test of time and proved to be an effective therapeutic modality in the treatment of advanced laryngeal malignancies.

Total laryngectomy remains a therapeutic option, as first-line therapy, in patients who are not suitable for organ preserving techniques or as "salvage surgery" for recurrence after partial laryngectomy or radiation techniques performed as first-line therapy.

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