**Conservation Laryngeal Surgeries**

The principles of management of the laryngeal cancer have evolved over the recent past with emphasis on organ preservation. These developments have paralleled technological advancements as well as refinement in the surgical technique. The surgeons are able to maintain physiological functions of larynx namely speech, respiration and swallowing without compromising the loco-regional control of cancer in comparison to the more radical treatment modalities. A large number of organ preservation surgeries are available to the surgeon; however, careful assessment of the stage of the cancer and selection of the patient is paramount to a successful outcome. A comprehensive review of various organ preservation techniques in vogue for the management of laryngeal cancer will be further discussed (Chawla and Carney, 2009).

Preservation of function is a prime consideration in all aspects of head and neck surgery. Conservation surgery of the larynx deals specifically with the goal of complete cancer excision while maintaining respiration, deglutition, and voice production. These results can be accomplished in the larynx by combining information on tumour behaviour with knowledge of the unique compartments and barriers in the larynx. The spectrum of conservation surgery is great, extending from microsurgical removal of superficial cancers of the true vocal folds to the more radical subtotal laryngectomy and partial laryngopharyngectomy. Approximately 50% to 70% of patients with cancers of the larynx have lesions amenable to conservation procedures (Tucker, 1989).
**Embryological development of the Larynx**

The unique embryology, compartmentalization of the larynx, and growth pattern of laryngeal cancer are the foundation for the principles of conservation surgery of the larynx (Silver, 1981). The larynx develops from three branchial arches. Supraglottic structures are derived primarily from the fourth arch, with the superior aspect related to the third arch. The glottis, cricoid cartilage, and subglottic areas arise from the sixth arch. This multiple-arch derivation results in horizontal segmentation of the laryngeal structures. Vertical segmentation exists as well because each half is paired from the respective arches.

**The horizontal and vertical segmentation of the Larynx**

The horizontal and vertical segmentation is significant because it provides intralaryngeal and extralaryngeal separation of the lymphatic drainage. Supraglottic structures drain to the superior deep cervical lymph nodes, and glottic and subglottic structures drain to the juguloomohyoid and inferior deep cervical lymph nodes. The apex of the piriform fossa (its most inferior portion) is on the same plane as the glottis and drains to the juguloomohyoid and inferior deep cervical lymph nodes.

Surface lymphatic vessels of the mucosa freely connect between the sides, but little connection exists between the lymphatic drainage of the glottic and supraglottic structures. The deeper submucosal lymphatic vessels remain in compartments according to the vertical and horizontal segmentation mentioned previously. The glottic region is relatively free of lymphatics. This is particularly true in the membranous true vocal folds within the mucosa and Reinke's space. Lateral to the vocal ligament and arytenoid, the muscular compartments are more vascular and contain significant numbers of lymphatic channels. The concentration
of lymphatic vessels increases toward the posterior one third, around the arytenoids and the interarytenoid space.

Figure (1): Embryological Divisions of larynx: Vertical and Horizontal divisions (Traissac et al., 1992)

**Anterior Commissure**

The anterior commissure must be considered separately (Bagatella and Bignardi, 1983). There is no internal perichondrium of the thyroid cartilage at this point, and the submucosa is closely applied to the cartilage. Anterior commissure cancers readily extend to the cartilage and inferiorly to the cricothyroid membrane. Here, the soft tissues and overlying Delphian lymph node may be involved.

**Pre-epiglottic Space**

The significant anterior relationship of the supraglottic structures is the preepiglottic space. This is bounded by the upper half of the thyroid cartilage, the thyrohyoid membrane, the thyroepiglottic ligament in the base of the vallecula, the infrahyoid portion of the epiglottis, and the thyroepiglottic ligament inferiorly. This space contains fibrofatty tissue and is rich in lymphatic vessels. The most common malignant tumor of the larynx, epidermoid carcinoma, grows slowly in
known patterns. In the majority of cases the tumor is moderately to well differentiate and has clearly defined margins of growth.

This, along with the distinct compartmentalization of the larynx mentioned previously, permits "millimeter surgery". This concept is seen most clearly with epiglottic cancers. Supraglottic laryngectomy may be performed even with tumor extending to within 3 to 4 mm of the anterior commissure and ventricle. Glottic cancers can be resected with only 2 to 3 mm of anterior or posterior margin on either side. Exceptions to this are when the tumor's growth pattern shows infiltrating margins or when multicentric disease is present (Bauer et al, 1975).

Aim of Conservation Laryngeal Surgeries
The main aim of conservative laryngeal surgery is to achieve the same local oncologic control of the disease offered by total laryngectomy, while enabling maintenance of adequate deglutition and speech by creating a neolarynx that keeps the cricoarytenoid cartilage intact (Majer & Rieder, 1959).
Furthermore, if there are no complications, the tracheostomy can be closed, thus eliminating a factor that causes patients great discomfort (Piquet et al., 1974). Several studies have already evaluated the oncologic results of this type of surgery, and the correct indications for surgery have been outlined (De Vincentiis et al., 1998).

**Principles of organ preservation**

The success of any organ preservation treatment modality rests on achieving a balance between effective loco-regional cancer control and maximal functional outcome.

The surgeon who endeavours to undertake organ preservation surgery should: (a) have a thorough understanding of the static and dynamic anatomy of larynx; (b) accurately assess the cancer both clinically and radiologically; (c) and have the training to competently perform the chosen surgical technique.

The principles of organ preservation surgery are: (Tufano, 2002)

1. Local control: regular and close follow up of the patient is imperative as changes in laryngeal topography with organ preservation techniques can make early detection of residual/recurrent disease difficult.

2. Accurate assessment of tumour extent- both surface spread and three dimensional tumour load rather than relying on the T-stage of the cancer. The drawbacks of current T-staging system will be discussed subsequently.

3. The Cricoarytenoid unit as the basic functional unit- traditionally, surgeons have focussed on the glottis/vocal cords as the key to phonatory and sphincteric functions of larynx. Since the popularisation of supracricoid laryngectomy, there has been a shift in this concept as explained subsequently.
4. Adhere to Standard resection technique to achieve expected functional outcome—
even if this involves resection of normal (uninvolved) tissue.

**Limitations of the current staging systems (Flint, 2002):**

1. Difference in histology and clinical behaviour between in-situ carcinoma and severe dysplasia can be unclear and this is not reflected by T-staging

2. Anterior commissure (AC) involvement has no impact on the T-stage of the tumour even though this is associated with poor cure and local control rates compared to equivalent lesions without AC involvement. The use of 1 mm thick reformatted CT scan images was shown to double the laryngoscopic accuracy in staging the cancer.

3. Motion impairment is a subjective measure with inter-observer variation accounting for possible staging errors of lesions between T1-2 and T2-3.

4. Size of lesion and its molecular characterisation (eg over-expression of p53 oncogene) are important determinants of tumour behaviour. These factors have not been accommodated in T-staging, which is based entirely on involvement of various subsites within and outside the laryngeal framework.

**Traissac in 1992 divided the conservation laryngeal surgeries into:**

**A. Vertical laryngectomies**

- Cordectomy
- Hemilaryngectomy
- Frontolateral Laryngectomy
- Frontal Laryngectomy

**B. Transverse laryngectomies**

- SupraGlottic
• **Glottic**

• **Supracricoid:** with CricoHyoidoPexy (CHP) or with CricoHyoidoEpiglottorPexy (CHEP)

*Frontolateral Vertical Hemilaryngectomy (FVHL)*

**Indication** (Sheen et al., 1998)

1. Large T1 glottic cancer - best results obtained when lesion is confined to middle third of vocal cord

2. Small T2 glottic cancer with minimal extension into supraglottis/subglottis

3. Early glottic cancer difficult to visualise endoscopically

4. Resection can be extended both anteriorly and posteriorly as well as beyond glottis

5. Salvage for radiotherapy failure of early-intermediate glottic cancer

**Reconstruction**

The petiole of epiglottis is sutured anteriorly to prevent posterior prolapse and supraglottic stenosis. The divided edges of the false and true cords on the uninvolved side are sutured to the external layer of perichondrium. Various materials can be used for reconstruction of glottis on the involved side: Pedicled/Bi-Pedicled muscle flap (Sternohyoid flap); mucosal flap (false vocal cord); epiglottic flap; deep cervical fascia (Apostolopoulos et al., 2002); corniculate-cuneiform flap (Persky and Damiano, 1998); free tissue transfer. A laryngeal keel may be used to prevent the formation of adhesions anteriorly, but is rarely required with good surgical technique. In absence of a tracheostomy, the skin wound can be closed loosely to allow air leak and prevent subcutaneous
emphysema. When reconstructing the glottis, the surgeon should be mindful of avoiding excessive soft tissue bulk, which can cause airway compromise.

Figure (3): Resection in FVHL (Traissac et al., 1992)

VPL offers several advantages over radiotherapy for management of early glottic cancer (Apostolopoulos et al., 2002).

1. Pathological staging of cancer possible
2. Easier to look for recurrence
3. Lower cost
4. Single treatment modality usually curative
5. Higher organ preservation rate

Supraglottic Partial Laryngectomy (SPL)

Supraglottic partial laryngectomy (SPL) has been reported in the 1940s for the first time, and it shows equal oncologic results with total laryngectomy, and also, functional preservation of swallowing and phonation is possible with this technique. In addition, the functional evaluation after SPL was limited to
parameters such as the time of decannulation, aspiration, and the ability for oral intake (Chawla & Carney, 2009).

**Supraglottic cancer poses unique management issues due to:**

1. Association with pre-epiglottic and paraglottic spaces

2. A rich lymphatic supply which is independent of the rest of larynx (leading to a higher risk of metastasis and recurrence) (Ogura, 1958).

3. Distinct anatomical boundaries due to its embryological origin from buccopharyngeal anlage

4. The need for treatment of the N0 neck with either adjuvant (chemo)-radiotherapy or selective neck dissection

**Reconstruction**

If possible, preservation of the hyoid provides a sturdier repair. The tongue base is sutured so as to impact onto the thyroid cartilage and act as a shelf to prevent aspiration. This allows food to be channelled into the pyriform sinuses. The laryngeal remnant should be positioned as far superiorly and anteriorly as possible.

*Figure (4): Resection in SPL (Traissac et al., 1992)*
Supracricoid Laryngectomy (SCL)

Supracricoid Laryngectomy (SCL) with CricoHyoidoPexy (CHP) is indicated in the case of tumors of the laryngeal vestibule that have spread to the glottis, whereas SCL with CricoHyoidoEpiglottioPexy (CHEP) is indicated in the case of tumors of the glottis that also affect the anterior commissure and both vocal folds, damaging the motility of one vocal fold. CHP includes the excision of the entire thyroid cartilage, the paraglottic spaces, the epiglottis, and the pre-epiglottic space. In CHEP, the excision includes the entire thyroid cartilage, the paraglottic spaces, and the lower part of the pre-epiglottic space; two thirds of the upper part of the epiglottis is conserved. In both surgical techniques, the hyoid bone, the cricoid cartilage, and at least one of the two arytenoid cartilages are conserved (Laccourreye et al., 1993; 1997).

Definition & Principle

Traditionally, the glottis has been deemed to be the functional unit of larynx in order to maintain physiologic speech and sphincteric function while swallowing. The concept of the Crico-Arytenoid unit (CAU) as the functional subunit of larynx is relatively new to the English literature but has been in vogue internationally since the 1990s. The vocal ligament and thyroarytenoid muscles provide refinement and exquisiteness to the range of speech. But the driving force for phonatory function is a mobile and sensate CAU.

According to this concept, speech and swallowing can made possible by preservation of one or both CAU with special attention to the attachment of posterior and lateral cricoarytenoid muscles – to allow the neo-glottis to abduct/adduct postoperatively. For a good functional outcome, all these structures (muscular, neovascular, cartilages) must be preserved.
Through anatomical-pathological studies, it has been shown that the cord fixation in laryngeal cancer results from involvement of the para-glottic space and invasion of the thyroarytenoid muscle. One of the main oncologic concepts of SCL is the excision of the entire para-glottic space, hence the thyroarytenoid muscle. It also allows complete excision of the lateral and posterior cricoarytenoid muscles if the arytenoid on the tumour bearing side is disarticulated and excised.

In SCL, membranous vocal cords, false cords and para-glottic spaces are excised (along with the entire thyroid cartilage). In addition, the pre-epiglottic space and epiglottis can be completely excised (although the lower 1/3rd of epiglottis is preserved in a CHEP). The arytenoid on the tumour-bearing side can be excised as governed by the requirement of an oncologic resection. However, it is absolutely essential to preserve one intact and sensate CAU and the cricoid cartilage (Ferlito et al., 2000).

Laryngeal reconstruction is accomplished using elements of the preserved crico-arytenoid unit(s) and a crico-hyoid impaction. For wound closure a "pexy" is done between cricoid and hyoid alone (SCPL-CHP) or using preserved portion of epiglottis to intervene between cricoid and hyoid (SCPL-CHEP). In selected cases, the anterior arch of cricoid can be resected and a tracheo-crico-hyoidoepiglottopexy (TCHEP) done by incorporating tracheal ring into the "pexy". Non-absorbable sutures (eg. Prolene) should be used to prevent wound breakdown and subsequent aspiration.

Compared to Vertical Partial Laryngectomy (VPL), SupraCricoidPartial Laryngectomy (SCPL) provides a more comprehensive resection of the para-glottic space; it can be used for cancers extending to the anterior commissure and can even be used for selective T4 lesions with minimal thyroid cartilage invasion (although this remains controversial). SCPL meets the criteria of organ
preservation; it restores physiological speech and swallowing and there is no need for a long-term tracheostomy.

The significance of SCL as an organ-preservation surgery to rescue selected laryngeal cancer patients has been well discussed and reported (Lima et al., 2006).

**Indication of SCL**

It is important to realise that the surgical management is dictated by peri-operative 3-D tumour assessment and not by the T staging of the cancer. Surgeons should be well familiar with the technique as it is technically more demanding than other forms of partial laryngeal surgery.

1. T1b/T2/T3 Glottic/Transglottic/Supraglottic cancer (when Supraglottic Laryngectomy is not appropriate)

2. Selected T4 Ca larynx-limited invasion of thyroid ala without extension through outer thyroid perichondrium (Yiotakis et al., 2003; Motamed et al., 2006; Wilson, 2000).  

![Figure (5): Resection in SCL (A): CHEP, (B): CHP (Traissac et al., 1992)](image_url)
Reconstruction

The arytenoid(s) need to be resuspended, as they tend to fall posteriorly due to the loss of thyro-arytenoid muscle. It is crucial to create a T shaped valve that will close against the epiglottis/base of tongue. The Arytenoids should not, however, be placed in contact with each other as post-operative synechiae can result in stenosis. Cricopharyngeal myotomy is done at the surgeon's discretion if hypertonia is detected in which case anti-reflux therapy should be commenced post-operatively. The 'pexy' is performed by placement of 3 or 5 impaction stitches approximately 8–10 mm apart, passing inferior to superior. An "inverted-funnel" shape of pyriform sinus is important for the pharyngeal phase of swallowing. This needs to be restored after SCPL. Two (3–0) Vicryl sutures are placed in fascia of inferior constrictor after impaction has been done and are tied anteriorly to the contralateral stitch. Pulling the lateral pharyngeal wall anteriorly restores its physiologic position and the function of inferior constrictors and PFS. A tight dressing is recommended to prevent surgical emphysema.

Care should be taken not to injure the SLN (according to some surgeons, dissection performed to specifically identify the nerve can cause bleeding and attempts to maintain hemostasis can result in nerve injury). Injury to the SLN leads to pooling in Piriform Fossae-Sinuses and has been associated with a higher incidence of aspiration and swallowing impairment. The AE folds are divided and bilateral ventricles inspected. Care is taken not to leave any mucosa behind to prevent laryngocele formation (Naudo et al., 1997).

Physiologic Aspects

Following SCL, speech is generated by the periodic mucosal wave on the anterior aspect of arytenoid cartilage where it abuts epiglottis (Ary-epiglottic type
phonation). It is comparable to normal speech for average fundamental frequency. However, it is less efficient in range, jitter, shimmer, noise: harmonics ratio, maximum phonation time, speech rate and phrase grouping (Holsinger et al., 2005).

Swallowing is usually restored in 2–3 weeks and requires intense rehabilitation. Prolonged requirement for feeding tube and tracheostomy is more common in previously irradiated patient undergoing salvage surgery. SCPL has been shown to offer higher quality of life compared to TL. In a study of quality of life assessment, higher score were given for physical and social functioning by patients undergoing SCPL; physical and general health and better voice quality compared to patients with TL. Several studies have shown the local control and survival rates to be similar to TL (Weinstein et al., 2000).

Radiotherapy after SCL is associated with negative influence on functional outcome and direct correlation has been demonstrated between radiotherapy dose and complication rate after laryngeal preservation surgery (Laccourreye et al., 2000).

In the early postsurgical phase after SCL, swallowing is always impaired because of inadequate neoglottic closure and thus tube feeding is required. Volitional sphincteric approximation of the mobile arytenoid cartilage and base of tongue, in the case of CHP, or epiglottis, in the case of CHEP, provides the mechanism to prevent aspiration and the mucosal source of vibration for voice production (Zacharek et al., 2001).
Supracricoid Laryngectomy has been reported as a suitable organ preservation surgery to rescue selected laryngeal cancer patients including advanced cases (Spriano et al., 2002).

However, functional aspects of the residual larynx other than the timing of postoperative decannulation or feeding tube removal have received little attention and limited measurements have been performed concerning the function of the neoglottis after SCL (Laudadio et al., 2006).

In a study done by Rifai et al. in 2010 on 333 patients who underwent Supracricoid laryngectomy, they concluded that it is effective for managing laryngeal cancer. Modification of the technique to permit resection of both arytenoids is possible in selected patients.

**Questions answered before deciding on CLS**

Of the patients whose laryngeal cancers are diagnosed each year in the USA, some are clearly irradiation candidates, whereas others are candidates for a conservation surgery approach. The patients in the "gray zone" are those whom the otolaryngologist - head and neck surgeon must evaluate carefully, using his or her skills as a total physician. The following questions should be asked in deciding whether to use radiotherapy or conservation surgery:

1. Is the patient's lesion amenable to the proposed primary therapy?
2. Is the patient a good medical candidate for the proposed therapy?
3. Is the patient able to afford the proposed treatment and prepared for its effects?
4. Does the patient have any biases, based on previous experience, toward the proposed therapy?
5. Is the therapist or surgeon skillful and experienced enough to produce the results predicted to the patient?

**Deccanulation**

Although early decannulation (in the first week after surgery) has recently been suggested to obtain an effective return to deglutition, some centers have always preferred to remove the tracheal cannula on completion of rehabilitation, when the patient can swallow without requiring tracheal aspiration of material accidentally inhaled. The time needed to restore per oral nutrition may range between two and four weeks, while adequate swallowing may only be achieved after several months (Weinstein et al., 2002).

As with all therapeutic challenges in medicine, the physician is ultimately faced with making a choice and must do this with the help of the patient. He or she must react in a responsible fashion and not use a "cookbook" method of determining treatment. Each patient must be evaluated individually, and the treatment plan should be based on personal and medical factors, gross and microscopic pathologic findings, and expertise of the available therapists.

Since its description by Majer and Rieder in 1959, supra-cricoid laryngectomy (SCL) with cricohyoidopexy has demonstrated that it can provide a good surgical alternative to the conventional partial and total laryngectomy in the treatment of specific glottis and supraglottic cancers (Brasnu, 2003).
Conservation laryngeal surgery and radiotherapy

The main advantage of conservative laryngeal surgery over total laryngectomy is that it preserves deglutition and speech, avoiding the need for a permanent tracheostomy (Weinstein et al., 2002).

Role of Radiotherapy in the management

Radiotherapy continues to be the most frequently used treatment for glottic carcinoma of the larynx in many oncological centers; however, recently changes have been instituted to this approach by more often offering surgical treatment for lesions in their early stages (Leslie et al., 2002).

In a study done, one of the most interesting aspects was the management of post-radiotherapy recurrences. Total laryngectomy continues to be the most used procedure for this. This is mainly due to the lack of experience in the techniques of conservative surgery of the larynx as well as to the notion of a marked increase of complications that some surgical groups have associated with partial laryngectomies. Surgical salvage treatment with SCL is possible in selected patients who seek medical care, presenting a similar clinical status to the initial condition and/or with progression but complying with the classical criteria established for this surgery (Hodgson et al., 2003).

The disadvantages of radiation therapy include long-term oncological problems and hidden costs such as work missed by the patient and family members, traveling time, and traveling distance. Furthermore, infiltration of the tumor into the cartilage of the anterior commissure was shown to significantly
decrease local control in patients treated with radiotherapy (Bron et al., 2001; Smith et al., 2003).

**LASER Conservation Laryngeal Surgeries**

Endoscopic carbon dioxide laser surgery has emerged as a major therapeutic option for patients with early glottic carcinoma. In experienced hands, oncological results similar to those achieved with primary radiotherapy or open surgery may be attained with endoscopic surgery (Steiner et al., 2004).

However, according to some authors, involvement of the anterior commissure by tumor is still considered a contraindication to endoscopic resection. Moreover, endoscopic resection of the anterior commissure is technically challenging for many surgeons (Bron et al., 2001).

The primary aim of laryngeal conservative surgery for glottis tumors is to achieve the same local control as is offered by total laryngectomy while conserving the functions of the larynx (Karasalihoglu et al., 2004).

**Role of endoscopic surgery in management of laryngeal cancer**

**Horace Green** was the first surgeon to attempt transoral resection of laryngeal tumor in 1852 (McWorther and Hoffman, 2005).

In the larynx, the technique involves complete excision of the lesion ideally with 2–3 mm circumferential margins. Particular attention is paid to the accurate orientation of the specimens. Biopsies are sent from the tumour bed for frozen section histopathological analysis. Positive margins necessitate a further surgical resection (Davis et al., 2004).
Endoscopic laser microsurgery has been reported to achieve local control rate in the range of 80–94% and organ preservation rate in up to 94% of the cases (Ambrosch, 2007).

An important advantage of this procedure is that in the event of local recurrence, it leaves open all other treatment options for laryngeal cancer including laser re-excision.

Endoscopic Vertical Partial Laryngectomy (EVPL) has evolved concurrently with the increasing expertise of surgeons in transoral laser resection of early laryngeal cancers and provides an organ preservation option for early-intermediate glottic cancer (T1, 2) (Davis et al., 2004).

Figure (6): Transoral laser excision of supraglottic cancer (Chawla & Carney, 2009)
Role of chemo-radiotherapy in organ preservation

Factors affecting outcome of primary Radiotherapy (Radiotherapy) are Anterior Commissure involvement, impaired vocal fold mobility, tumour bulk and fraction size (Kadish, 2005).

It used to be generally agreed that the voice quality following primary RT was superior to open partial procedures. This view has been challenged in recent studies. A meta-analysis conducted in 2006 showed that both RT and endoscopic laser microsurgery provide comparable level of voice handicap for T1 glottic cancers (Cohen et al., 2006).

The basis of voice impairment following irradiation is the damage to microstructure of the vocal folds (fibrosis, oedema, and irregularity in the vocal folds) impairing the generation of the mucosal wave. Other factors contributing to poor voice quality include loss of salivary glands and mucositis. Surgery offers the advantage of sparing trauma to the uninvolved fold as well as providing phonosurgical options to repair the post surgical defects.

In another meta-analysis study by Luscher and his colleagues, treatment of T1 glottic cancer using radiotherapy and laser were compared. Laser was found to be the cheaper option with lower recurrence rates. However, in three out of six studies, radiotherapy resulted in superior voice quality (In remaining three studies, no difference was noted) (Luscher et al., 2001). Higher overall cost of RT has been reported in other studies as well (Smith et al., 2003).
**Deglutition Disorders**

Swallowing is a complex and coordinated neuromuscular process, which consists of both voluntary and involuntary activity. It is described as involving three anatomically and temporally distinct phases: the oral, the pharyngeal, and the oesophageal phases (Cunningham et al., 1996).

Swallowing is also defined as a complex function that involves the mouth, pharynx, larynx and oesophagus. The swallowing process has four phases (Palmer, 2000):

- Oral preparation: This phase refers to processing of the food bolus to prepare it for swallowing.
- Oral propulsive: This phase refers to propelling food from the oral cavity to the back of the mouth.
- Pharyngeal: This phase refers to the action of moving food into the pharynx to propelling the bolus down.
- Esophageal: This phase refers to the food bolus moving down the esophagus to the stomach with a peristaltic wave.

Swallowing is also defined as the ability to carry a solid, liquid, gaseous or mixed texture bolus from the mouth to the stomach keeping food and liquids out of the larynx, thanks to a combination of functions that stop food and liquids from entering the larynx; dysphagia derives from an impairment of one or more of these functions, at their origin or of their coordination (Schindler et al., 2001).
Normal Swallowing

Normal swallowing is a complex process that requires the coordination of voluntary and involuntary actions. After oral acceptance and preparation, a food bolus is voluntarily delivered to the pharynx. This triggers the involuntary pharyngeal phase in which the soft palate seals the nasopharynx, the larynx is elevated and tilted anteriorly, the true and false vocal folds close and the pharyngeal constrictors sequentially contract to propel the bolus into the oesophagus. The upper oesophageal sphincter simultaneously relaxes and is pulled open to accept the bolus through laryngeal elevation. Peristalsis then transports the bolus to the stomach (Schindler et al., 2001).

Physiology

Two paradigmatic models are commonly used to describe the physiology of normal eating and swallowing: the Four Stage Model for drinking and swallowing liquid, and the Process Model for eating and swallowing solid food. The normal swallow in humans was originally described with a three-stage sequential model. The swallowing process was classified into oral, pharyngeal, and esophageal stages according to the location of the bolus.

The oral stage was later subdivided into oral preparatory and oral propulsive stages, and the four stage model was established. Studies based on the four stage model adequately describe biomechanics and bolus movement during command swallows of liquids. However, this model cannot represent the bolus movement and the process of eating of solid food. Therefore, the Process Model of Feeding was established to describe the mechanism of eating and swallowing of solid food (Matsou and Palmer, 2008).
Oral preparatory stage

After liquid is taken into the mouth from a cup or by a straw, the liquid bolus is held in the anterior part of the floor of the mouth or on the tongue surface against the hard palate surrounded by the upper dental arch (upper teeth). The oral cavity is sealed posteriorly by the soft palate and tongue contact to prevent the liquid bolus leaking into the oropharynx before the swallow. There can be leakage of liquid into the pharynx if the seal is imperfect, and this leakage increases with aging (Matsuo and Palmer, 2008).

Oral propulsive stage

During oral propulsive stage, the tongue tip rises, touching the alveolar ridge of the hard palate just behind the upper teeth, while the posterior tongue drops to open the back of the oral cavity. The tongue surface moves upwards, gradually expanding the area of tongue-palate contact from anterior to posterior squeezing the liquid bolus back along the palate and into the pharynx. When drinking liquids, the pharyngeal stage normally begins during oral propulsion (Matsuo and Palmer, 2008).

Oral stage in eating solid food (Process Model of Feeding)

The four stage sequential model has limited utility for describing the process of normal eating in humans, especially food transport and bolus formation in the oropharynx. When healthy subjects eat solid food, triturated (chewed and moistened) food commonly passes through the fauces for bolus formation in the oropharynx (including the valleculae) several seconds prior to the pharyngeal stage of a swallow.

Additional portions of food can pass into the oropharynx and accumulate there while food remains in the oral cavity and chewing continues. This
phenomenon is not consistent with the four stage model, because of the overlap among the oral preparatory, propulsive and pharyngeal stages. The observable events during feeding on solid food are better described with Process Model, which has its origin in studies of mammalian feeding and was later adapted to feeding in humans (Matsuo and Palmer, 2008).

1) Stage I transport:

When food is ingested into the mouth, the tongue carries the food to the post-canine region and rotates laterally, placing the food onto the occlusal surface of lower teeth for food processing.

2) Food Processing:

Food processing immediately follows stage I transport. During food processing, food particles are reduced in size by mastication and softened by salivation until the food consistency is optimal for swallowing. Chewing continues until all of the food is prepared for swallowing. Cyclic movement of the jaw in processing is tightly coordinated with the movements of the tongue, cheek, soft palate and hyoid bone.

During drinking of liquid, the posterior oral cavity is sealed by tongue-palate contact during the oral preparatory stage when the bolus is held in the oral cavity. In contrast, during food processing, the tongue and soft palate both move cyclically in association with jaw movement, permitting open communication between the oral cavity and pharynx. Therefore, there is no sealing of the posterior oral cavity during eating.

Movements of the jaw and tongue pump air into the nasal cavity through the pharynx, delivering the food's aroma to chemoreceptors in the nose. Cyclical tongue movement during processing is coordinated with jaw movement. Tongue
movements during processing are large in both the antero-posterior and vertical dimensions; jaw movements are similarly large in the vertical dimension (Matsuo and Palmer, 2008).

3) Stage II transport

When a portion of the food is suitable for swallowing, it is placed on the tongue surface and propelled back through the fauces to the oropharynx. The basic mechanism of stage II transport is as described for the oral propulsive stage with a liquid bolus. The anterior tongue surface first contacts the hard palate just behind the upper incisors. The area of tongue-palate contact gradually expands backward, squeezing the triturated food back along the palate to the oropharynx.

Stage II transport is primarily driven by the tongue, and does not require gravity. Stage II transport can be interposed into food processing cycles. The transported food accumulates on the pharyngeal surface of the tongue and in the valleculae. If food remains in the oral cavity, chewing continues and the bolus in the oropharynx is enlarged by subsequent stage II transport cycles. The duration of bolus aggregation in the oropharynx ranges from a fraction of a second to about ten seconds in normal individuals eating solid food (Matsuo and Palmer, 2008).

Pharyngeal stage

Pharyngeal swallow is a rapid sequential activity, occurring within a second. It has two crucial biological features: (1) food passage, propelling the food bolus through the pharynx and UES to the esophagus, (2) airway protection, insulating the larynx and trachea from the pharynx during food passage to prevent the food from entering the airway.

During the pharyngeal stage, the soft palate elevates and contacts the lateral and posterior walls of the pharynx, closing the nasopharynx at about the same time that the bolus head comes into the pharynx. Soft palate elevation prevents bolus
regurgitation into the nasal cavity. The base of the tongue retracts, pushing the bolus against the pharyngeal walls. The pharyngeal constrictor muscles contract sequentially from the top to the bottom, squeezing the bolus downward. The pharynx also shortens vertically to reduce the volume of the pharyngeal cavity.

Safe bolus passage in the pharynx without aspirating food is critical in human swallowing. There are several airway protective mechanisms preventing aspiration of the foreign materials to the trachea before or during swallowing. The vocal folds close to seal the glottis (space between the vocal folds) and the arytenoids tilt forward to contact the epiglottic base prior to opening of the UES.

The hyoid bone and larynx are pulled upward and forward by contraction of the suprahyoid muscles and thyrohyoid muscle. This displacement tucks the larynx under the base of the tongue. The epiglottis tilts backward to seal the laryngeal vestibule. The mechanism of the epiglottic tilting in human swallowing remains unclear, but is probably related to hyo-laryngeal elevation, pharyngeal constriction, bolus movement, and tongue base retraction (Matsuo and Palmer, 2008).

Opening of the upper esophageal sphincter (UES) is essential for the bolus entry into the esophagus. The UES consists of the inferior pharyngeal constrictor muscles, cricopharyngeous muscle and most proximal part of the esophagus. The UES is closed at rest by tonic muscle contraction.

Three important factors contribute to the UES opening: 1) Relaxation of the cricopharyngeous muscle; this relaxation normally precedes opening of the UES or arrival of the bolus. 2) Contraction of the suprahyoid muscles and thyrohyoid muscles. These muscles pull the hyo-laryngeal complex forward, opening the
sphincter. 3) The pressure of the descending bolus. This pressure distends the UES, assisting its opening. The most important of these mechanisms is #2, the active opening process. This makes opening of the UES quite different from other sphincters (such as the external urethral sphincter that open passively: the urethral sphincter relaxes and is pushed open by the descending fluid bolus (Matsuo and Palmer, 2008).

**Esophageal stage**

The esophagus is a tubular structure from the lower part of the UES to the lower esophageal sphincter (LES). The lower esophageal sphincter is also tensioned at rest to prevent regurgitation from the stomach. It relaxes during a swallow and allows the bolus passage to the stomach. The cervical esophagus (upper one third) is mainly composed of striated muscle but thoracic esophagus (lower two thirds) is smooth muscle. Bolus transport in the thoracic esophagus is quite different from that of the pharynx, because it is true peristalsis regulated by the autonomic nervous system (Matsuo and Palmer, 2008).

Once the food bolus enters the esophagus passing the UES, a peristalsis wave carries the bolus down to stomach through the LES. The peristaltic wave consists of two main parts, an initial wave of relaxation that accommodates the bolus, followed by a wave of contraction that propels it. Gravity assists peristalsis in upright position (Matsuo and Palmer, 2008).
Swallowing Abnormalities

Difficulty with swallowing is also referred to as dysphagia. This condition is also known as a deglutition disorder. Pain in swallowing may accompany dysphagia, and this is referred to as odynophagia. An inability to swallow is known as aphagia. Consequences of dysphagia and feeding disorders may be severe and may include: dehydration, malnutrition, aspiration, choking, pneumonia, and death (Smith Hammond and Goldstein, 2006).

Dysphagia after Conservation Laryngeal Surgeries (CLS)

The principal reason for the swallowing impairment, in patients with conservation laryngeal surgeries (CLS), is mechanical, consisting in incontinence of the glottic sphincter due to surgery-related anatomical modifications. Moreover, this impairment could be related to specific sensorial or motor deficits of the laryngeal mucosa on account of the lesions of the superior or inferior laryngeal nerve. In subtotal reconstructive laryngectomy, difficult recovery of normal oral
intake and aspiration is often possible during the first swallowing attempts immediately after surgery, with the risk of aspiration pneumonia. For this reason, there is a suspension of oral intake immediately after surgery that can last for a few days or even weeks and, to ensure spontaneous breathing, to prevent aspiration of feeding material and to guarantee adequate alimentation, the patient is assisted with a feeding tube and a tracheotomy tube (Coscarelli et al., 2007).

Dysphagia is a constant complication of subtotal reconstructive laryngectomy, due to modifications in the anatomy and in sensitivity of the larynx and pharynx. The reduced sphincteric activity of the larynx can enhance aspiration with a higher risk of pneumonia which could be a life threatening condition.

Oral dysphagias include impairment in preparing the bolus for the swallow (difficulty with mastication), delayed triggering of the swallow, incomplete swallow (residue left in the oral cavity after the swallow), and premature entry of the bolus into the pharynx (with possible entry into the unprotected airway). Disorders in the pharyngeal stage of the swallow include pooling in the valleculae or pyriform sinuses (with consequent risk of aspiration), penetration into the laryngeal vestibule with or without actual aspiration, aspiration, reduced or absent laryngeal elevation (preventing the cricopharyngeal sphincter from opening), and delayed or absent cricopharyngeal opening (Martin-Harris et al., 2000).

Aspiration

An intrinsic abnormality in the effectiveness, duration, or timing of any of the components of swallowing can result in aspiration (Sheikh et al., 2001).
Aspiration is also defined as the misdirection of oropharyngeal or gastric contents into the larynx and lower respiratory tract (Marik, 2001).

Aspiration represents the repeated passage of food material, gastric refluxate, and/or saliva into the subglottic airways in a manner sufficient to cause chronic or recurrent respiratory symptoms. These symptoms include chronic cough, wheeze, recurrent pneumonia, failure to thrive, choking on food or secretions, and radiological signs of chronic lung injury (Owayed et al., 2000; Lodha et al., 2002).

**Classification of Aspiration**

Aspiration can be classified according to the time of its occurrence as pre-, intra- or post-deglutitive (before, during, or after swallowing). The frequency of post-deglutitive overflow aspiration was found to be directly related to pharyngeal retention in the piriform sinuses or valleculae (Lodha et al., 2002).

An aspiration event can occur at 3 points during the oropharyngeal swallow (before, during, or after), because of temporal or biomechanical disruptions to the critical and physiologically complex components involved in swallowing. Evidence suggests that patients with dysphagia have a greater than 7-fold chance of acquiring aspiration pneumonia if they are found to aspirate during an MBS examination (Logemann et al., 2003).

Aspiration was quantified by the degree of severity: mild, moderate, or severe. Mild aspiration constituted less than 10% of the barium bolus; moderate aspiration, up to 25% of the bolus; and severe aspiration, more than 25% of the bolus (Lodha et al., 2002).
Some causes of Aspiration

In some patients, penetration or aspiration may occur due to leaking or delayed triggering of pharyngeal contraction, resulting in aspiration before swallowing, or due to incomplete laryngeal closure, resulting in aspiration during swallowing. Pharyngoesophageal sphincter dysfunction can be divided into four types: delayed opening, incomplete opening, premature closure, and prolonged opening on swallowing. Other causes of obstruction at the level of the pharyngoesophageal sphincter (cervical osteophytes, strictures, webs) should be assessed (Frederick et al., 1996).

The threshold of what constitutes pathological aspiration in a given individual may vary. Determining whether aspiration is a significant cause of respiratory disease can thus be challenging (Huxley et al., 1978).

Studies have demonstrated a temporal, physiologic link between breathing and the principal physiologic swallowing components involved in airway protection during swallowing. A normative model of integrated breathing and swallowing patterns has been suggested by Cedborg et al., in 2009. Emerging technology makes the synchronous recording of breathing and swallowing possible, reliable, and clinically practical, leading to the establishment of normative data regarding this patterned coordination (Martin Harris et al., 2003).

Preserved swallow function and the cough reflex are important defenses against oropharyngeal aspiration, with abnormalities of both increasing the risk of aspiration pneumonia. Approximately half of all healthy adults aspirate small amounts of oropharyngeal secretions during sleep (Gleeson, 1997).
Temporal relationship between swallowing and respiration

The phases of respiration (inspiration, expiration), interrupted by the swallow and resumed during the late stage of the pharyngeal swallow, were recorded to determine respiratory-phase pattern. These 11 events were apnea onset, oral bolus transport, laryngeal closure, hyoid excursion, PES opening, maximum laryngeal closure, maximum hyoid excursion, laryngeal opening, last PES opening, apnea offset (APOff), and hyoid return to rest (Martin-Harris et al., 2003).

The pharynx is the common conduit for gasses during breathing and for food and drink during swallowing, yet it has been only just more than a decade that researchers have truly explored the coordination of breathing and swallowing. Breathing and swallowing are physiologically linked to ensure effortless gas exchange during oronasal breathing and to prevent aspiration during swallowing. The contribution of discoordinated breathing and swallowing to the occurrence of aspiration pneumonia in patients with dysphagia remains unknown (Martin Harris et al., 2003).

Because alterations in pulmonary defenses and changes in the speed and efficiency of swallowing occur with healthy aging, this establishment of normal breathing and swallowing patterns is critical to understanding the contribution of its aberrations to aspiration and to the development of aspiration pneumonia (Nicosia et al., 2000).

Consistent temporal relationships between phase of respiration and swallowing have been found. The onset of hyoid excursion occurred during expiration in 47% and during a pause in respiration in 50% of swallows. Hypopharyngeal transit of the bolus was initiated during a pause in breathing for
every swallow and nearly always ended with expiration or a pause in breathing after bolus passage to the esophagus. Resumption of respiration in exhalation may help prevent inhalation of residual food in the piriform sinuses or hypopharynx after swallowing (Nishino and Hiraga, 1991). Mechanical factors may place constraints on the coordination of respiration and swallowing, as noted by Charbonneau et al. in 2005.

At the onset of swallowing, elevation of the larynx contributes to airway protection. In addition, there is shortening of the pharynx, which reduces the volume of pharynx and is a component of pressure generation during the swallow (Palmer et al., 2000).

The larynx is tethered by its attachment to the trachea, which is in turn attached to the lungs and indirectly connected to the diaphragm. When the diaphragm contracts in inspiration; it pulls downward on the trachea and, thereby, on the larynx. This downward pull on the larynx can impede laryngeal elevation. Swallow onset, defined as the start of elevation of the hyoid, occurred during inspiration in only 3% of swallows. Swallowing during expiration (while the diaphragm is rising) or during a pause in respiration (when the diaphragm is relaxed) may facilitate elevation of the larynx and shortening of the pharynx (Charbonneau et al., 2005).

Mechanisms for preventing aspiration during bolus aggregation remain unclear. As shown in previous studies, respiration is not affected by bolus aggregation in the valleculae, so some other mechanism(s) must be responsible. Dua et al. in 1997 reported that there are other alternatives mechanisms: partial
vocal fold closure when food reaches the valleculae; this could prevent aspiration by limiting access to the larynx from above.

Aspiration may occur as a result of swallowing dysfunction, gastro-oesophageal reflux disease (GERD), or an inability to protect the airway adequately from oral secretions. In patients with aspiration, more than one mechanism is often involved and the condition may be due to structural and/or medical condition

**Definitions for Bolus Flow Measures and Physiologic Components of Swallowing- Component Operational Definition**

- Oral bolus transport: Posterior movement of bolus tail via superoposterior tongue movement (defined at time 0 [t0], from which all other measures were calculated)
- Apnea onset: Plateau in respiratory trace along abscissa
- Bolus position at posterior angle of ramus of mandible
- Bolus head arrival at posterior angle of ramus of mandible
- Hyoid excursion: Superior and anterior movement of hyoid bone
- Laryngeal closure: Forward displacement of arytenoids cartilages to epiglottic petiole
- Maximum laryngeal closure: Maximum contact of arytenoids cartilages to epiglottic petiole
- Pharyngoesophageal segment opening
- Forward displacement of cricoids cartilage from posterior pharyngeal wall
- Maximum hyoid excursion: Highest and most forward movement of hyoid bone
- Last pharyngoesophageal segment opening
- Last point in time when pharyngoesophageal segment is open
- First laryngeal opening: Separation of arytenoid cartilages from epiglottic petiole
- Apnea offset: Departure from plateau in respiratory trace along abscissa in positive or negative direction
- Hyoid return to rest Point at which hyoid has moved (from its most superior and anterior position) to stable, relaxed position (Martin-Harris et al., 2005)

**Gastro-Esophageal Reflux Disease (GERD) & Aspiration**

Although an association between Gastro-Esophageal Reflux Disease (GERD) and respiratory symptoms, such as wheezing, chronic cough, nocturnal cough, apnoea and recurrent lung infections, has been well documented, several studies provide evidence substantiating a cause-and-effect relationship between GOR and aspiration. Observational evidence suggests that medical and surgical treatment of GERD may decrease lung infections (Phua et al., 2005).

**Saliva & Aspiration**

Chronic aspiration of saliva is the least-commonly recognised form of aspiration and is usually not diagnosed prior to the development of significant lung injury. The oral cavity contains potentially pathogenic bacteria and yeast. These organisms can cause recurrent pneumonia or pulmonary abscess if aspirated in sufficient quantity (Brook and Finegold, 1980).
Head and Neck Cancer & Aspiration

Aspiration is the most threatening complication following treatment for head and neck cancer. Malnutrition, compromised pulmonary function, anxiety, and depression are well known sequelae of aspiration. All treatment modalities of head and neck cancer can induce aspiration in cancer survivors (Eisbruch et al., 2002; Nguyen et al., 2005).

Causes of postoperative aspiration include:

1. Wide resection of the tumor with a rim of normal tissue produces damage to muscles critical to deglutition.
2. Excessive scarring induced by radiation or chemoradiation which can alter the coordination of different phases of deglutition.
3. In addition, radiation-induced xerostomia may lead to poor oral hygiene and oropharyngeal colonization with pathogenic bacteria.
4. Cancer patients often have impaired immunity because of malnutrition, and cancer therapy such as chemotherapy. When aspiration pneumonia develops, it is often fatal (Smith et al., 2000; Nguyen et al., 2004; Kilawada et al., 2005).

Dynamic modifications of deglutition after CLS

The most frequent dynamic modifications of deglutition after CLS are reduced movement of back tongue, delayed triggering of pharyngeal swallow, reduced pharyngeal wall contraction, upper esophageal sphincter (UES) opening dysfunction, stasis in the hypopharynx, and increased oropharyngeal transit (Woisard et al., 1996).
Radiation therapy & Aspiration

Radiation therapy can produce secondary fibrosis of the pharyngeal muscles and soft tissues, with resultant impairment of pharyngeal contraction and laryngeal elevation, and inclusion of salivary glands into the radiation field results in xerostomia and hyposalivation, which further impair mastication and the initiation of the swallowing reflex (Hamlet et al., 1997).

However, the impairment of swallowing and phonation caused by radiation therapy is being reported by many studies and excellent treatment results of surgical methods that have been under-evaluated in terms of functional preservation have been reported, and so, re-evaluation of its appropriateness as the initial treatment of laryngeal carcinomas is considered necessary (Kotz et al., 2004).

Chemoradiation & Aspiration

However, the effectiveness of swallowing therapy or rehabilitation has not been thoroughly tested in patients who develop aspiration following postoperative radiation or chemoradiation. This information may become important for the clinician, as concurrent chemoradiation becomes more popular because of its anatomic organ preservation. The combined modality is associated with high aspiration prevalence (Kotz et al., 2004).

As a prelude to broader application of swallowing therapy and other techniques to mitigate aspiration and its sequelae and because of the scarcity of reports on the course of aspiration in these patients, this retrospective review of past experience at large medical centers was taken. Prolonged and debilitating
functional swallowing abnormalities may occur after this aggressive concomitant chemotherapy and radiotherapy regimen (Graner et al., 2003).

The medical, social, and psychological impact of dysphagia is significant, with dysphagia in the patients often being under recognized and poorly diagnosed and managed. Dysphagia is the major pathophysiologic mechanism leading to aspiration pneumonia. Dysphagia has a negative impact on the quality of life for those suffering from it. Awareness of dysphagia in the population, the diagnostic procedures, and treatment options available should be increased among the medical profession (Ekberg et al., 2002).
**Assessment of Deglutition**

The need for professional management of dysphagic patients is growing. The scenario of patient care settings spans from the acute ward to chronic care facilities or home, requiring a health care network able to integrate hospital and community resources and optimise human and instrumental resources. This is also valid for Swallowing Centres, where admission, management, treatment and follow-up of discharged patients are a priority. The complexity of symptoms and the specificity of the underlying disease require a multidisciplinary approach to the patient. The coordinator of the Swallowing Centre is a phoniatrician. Patient management and personalized therapeutic options are discussed collegially. The phoniatrician, coordinating the activity of other therapists in the Centre, is responsible for patient treatment. In addition, the phoniatrician is responsible for counselling patients, nurses and informal caregivers (Andrea et al., 2009).

**No gold-standard diagnostic tests for aspiration**

There are no gold-standard diagnostic tests for aspiration. Currently, the diagnosis of aspiration is made clinically with some supporting diagnostic evaluations. Owing to the complex nature of chronic aspiration, a multidisciplinary approach is optimal. All patients with clinical signs suggestive of dysphagia and pneumonia should be referred for a swallow evaluation. Patients with dysphagia require a multidisciplinary approach to swallowing management, aggressive oral care, and consideration for treatment with a Proton pump inhibitor (Ekberg et al., 2002).
History and Physical Examination

Evaluation of swallowing and feeding disorders first includes performing a history and physical exam. Objectives of the history should include: identifying the anatomic region involved and obtaining clues to the etiology of the condition. This may include information regarding the onset, duration and severity, presence of regurgitation, the perceived level of obstruction and presence of pain or hoarseness, and presence of other disorders. During the physical examination, the patient should be observed during the act of swallowing.

Clinical evaluation of dysphagia

A clinical dysphagia evaluation is usually completed by a phoniatrician. The examination will include: assessment of posture, positioning, patient motivation, oral structure and function, efficiency of oral intake and clinical signs of safety. A variety of positions, feeding techniques and adaptive utensils may be used during the examination.

Evaluation of the postoperative outcome on swallowing

In patients submitted to ENT or maxillo-facial surgery, an evaluation is made of the outcome of the surgical treatment on “oral-pharyngeal-oesophageal pulsive pump” function which is moved by the tongue, the pharynx and the oesophagus, which squeezes the bolus from the mouth to the stomach, crossing five unidirectional valves: lips, velo-pharyngeal sphincter, larynx; superior oesophageal sphincter, inferior oesophageal sphincter (Ricci et al., 2007).
**Clinical Assessment**

A clinical assessment evaluates the structure and function of the swallow impairment of the oral stage. It enables the prediction of the impairment of the pharyngeal, laryngeal, and esophageal swallow physiology. The findings from the clinical evaluation will determine appropriate management, specific treatment strategies, and the need for appropriate instrumental testing. The clinical assessment includes a comprehensive medical and swallowing history, an oral motor and sensory evaluation, and the patient swallowing food and liquid of varying consistencies and at various calibrated volumes. Oral control, lingual activity, oral residue, initiation of laryngeal elevation, laryngeal excursion, voice quality, and cough after swallow are some of the key clinical parameters observed during the clinical assessment (Wooi et al., 2001).

The swallow assessment may be performed with or without the use of cervical auscultation, pulse oximetry, or use of food colouring with tracheotomised patients. Therapeutic strategies such as altering food textures, head postures, and specific manoeuvres may be also be tested. Education and recommendations regarding management is provided, and the need for further testing is determined. Available evidence, although limited, suggests that a full clinical assessment may have approximately 80% sensitivity and 70% specificity for detecting aspiration in adults (Palmer et al., 2001).

Clinical non-instrumental evaluation plays an important role in the assessment of the dysphagic patient. This evaluation, called “bedside examination”, aims to establish whether dysphagia is present, evaluating severity,
determining the alterations which cause it, planning rehabilitation, testing outcome of treatment. The assessment takes into consideration the swallowing problem, evaluation of the anatomy and functionality, of sensitivity and the reflexes, of the swallowing apparatus. Finally, the oral feeding test is performed, which evaluates the oral and pharyngeal phases of swallowing. The examination performed in the neurologic patient is different from that performed in the patient submitted to ENT or maxillo-facial surgery.

**Clinical Signs Suggesting the Presence of Dysphagia**

- Difficulty managing secretions
- Drooling of secretions or food from the mouth
- Delay in triggering the swallow
- Coughing or choking before, during, or after the swallow
- Wet, gurgly voice quality after the swallow
- Reduced or absent thyroid/laryngeal elevation during swallow Attempts.
- Multiple swallows per mouthful
- Food or liquid leaking from the nose
- Pocketing of food in the oral cavity
- Slow rate or very rapid rate of oral intake
- Prolonged oral preparation with food
- Significantly increased time to complete a meal
- Unusual head or neck posturing while swallowing
- Pain with swallowing
- Decreased oral/pharyngeal sensation (Wooi et al., 2001)
**The instrumental evaluation**

The instrumental evaluation supplements the clinical assessment. It enables the clinician to further evaluate the structure and function of the oral, pharyngeal, laryngeal, and upper oesophageal swallow physiology, as well as assess the benefit of compensatory and treatment strategies (*Wooi et al., 2001*).

**Clinical Bedside Instrumental Evaluation**

**Fiberoptic-endoscopic evaluation of swallowing**

Fiberoptic endoscopic evaluation of swallowing (FEES) is an adjunct to clinical assessment and provides detailed information about the anatomy and physiology of the pharynx and larynx, with the assessment of the pharyngeal phase of swallowing. It requires the transnasal passage of a flexible laryngoscope into the hypopharynx. Food and liquid are presented in the same manner as during the clinical examination. FEES is an assessment tool that can be administered at the bedside and is suitable for serial testing (*Martino et al., 2000*).

Since the introduction of flexible endoscopy for the assessment of dysphagia in 1988, its use has continued to expand. The study can be performed in patients of any age and requires no sedation or exposure to radiation. A small flexible nasopharyngoscope is positioned between the soft palate and epiglottis and multiple swallows are visualised directly via a video monitor. The oral and pharyngeal phases can be assessed but the scope is blind to events occurring during pharyngeal contraction. As with videofluoroscopic swallow studies (VFSS), patients can be fed the same food they are given at home, the consistencies can be varied and the effectiveness of implemented compensatory and therapeutic swallowing techniques can be assessed at the time of examination. The ability of the caregiver
to observe the aspiration event as well as the effectiveness of feeding techniques directly provides strong feedback and reinforcement (Martino et al., 2000).

As mentioned above, FEES can be a very useful examination in those who are not feeding orally but continue to have symptoms of aspiration. Aspiration of oral secretions can be directly visualised or impending aspiration can be determined by the presence of pooled secretions in the larynx and diminished laryngeal sensitivity. Laryngeal sensation can be quantified by applying graded bursts of air to the aryepiglottic fold and documenting the threshold pressure required to elicit the laryngeal adductor reflex. Both pooled oral secretions and decreased laryngeal sensation predict aspiration without challenging the patient with an oral bolus (Perlman et al., 2004).

**FEES provides information regarding the following:**

- Adequacy of the oral phase
- Premature spillage
- High position
- Subjective perception of the bolus
- Pooling in vallecule (hypopharynx)
- Site trigger
- Pre-swallowing Inhalation
- Glottic closure
- Intra-swallowing Inhalation
- Site, amount and management of the pooling
- Post-swallowing Inhalation
- Effectiveness of manoeuvres and postures
- Protection for the low respiratory tract (Perlman et al., 2004).
Radiological Evaluation of Swallowing

Pre-operative Barium Swallow

Phoniatricians are an important part of the rehabilitation team. Special training in swallowing therapy is essential in working with conservation surgery patients. The speech therapist should review the barium swallow result pre-operatively to determine whether a special swallowing study is necessary for delineating pre-existing swallowing problems. Longstanding articulation problems may play a major role in post-treatment fluency and discrimination. Postoperative voice recordings and overall assessment of speech, voice, and swallowing functions are useful to rehabilitation. Special strategies are necessary to rehabilitate patients who have had hemiglottic or supraglottic laryngectomies. Involvement of the speech therapist also indicates to the patient that the surgeon is concerned about voice, communication, and swallowing needs (Marchese-Ragona et al., 2003).

The barium swallows may also detect pre-existing problems with deglutition at the upper and lower esophageal sphincters, primary esophageal motor disorders, and hiatal hernias with reflux. The presence of any of these conditions preoperatively must be accounted for in the postoperative rehabilitation period. This is important information in determining the eligibility of patients for conservation surgery of the larynx because of the marked alterations in deglutition this surgery produces (Marchese-Ragona et al., 2003).

During the Modified Barium Swallow (MBS) procedure, the patient is either sitting or standing and viewed in frontal and lateral planes. The fluoroscopy tube is positioned to view the oral cavity anteriorly, the soft palate superiorly, the posterior pharyngeal wall posteriorly, and the seventh cervical vertebra inferiorly.
In this way, the oral preparatory, oral, pharyngeal, and cervical esophageal phases of deglutition could be assessed and viewed simultaneously. Seven consistencies of food and liquid were introduced by teaspoon to the patient. Water, liquid barium, apple sauce, mashed potatoes, green beans, ground meat, and sliced meat mixed with barium paste were used in the assessment. With each swallow, the patient was instructed to hold the material in his mouth until told to swallow (Presutti & Bergamini et al., 2010).

**Observations**

1. Residue on the tongue or in the pharynx after the swallow.
2. Laryngeal penetration or aspiration during or after the swallow.
3. Backflow
5. Disordered peristalsis in the pharynx or esophagus was noted.

The patient was then repositioned in the anterior–posterior position and presented with at least two additional consistencies.

**Each patient is scored using the Swallowing Performance Scale** (Presutti & Bergamini et al., 2010).

- **Grade 1**: Normal.
- **Grade 2**: Within functional limits: abnormal oral or pharyngeal stage but able to eat a regular diet without modifications or swallowing precautions.
- **Grade 3**: Mild impairment: mild dysfunction in oral or pharyngeal stage, requires a modified diet without need for therapeutic swallowing precautions.
- **Grade 4**: Mild-to-moderate impairment with need for therapeutic precautions: mild dysfunction in oral or pharyngeal stage, requires a modified diet and therapeutic precautions to minimize aspiration risk.
Grade 5: Moderate impairment: moderate dysfunction in oral or pharyngeal stage, aspiration noted on exam, requires a modified diet, and swallowing precautions to minimize aspiration risk.

Grade 6: Moderate–severe dysfunction: moderate dysfunction of oral or pharyngeal stage, aspiration noted on exam; requires a modified diet and swallowing precautions to minimize aspiration risks; needs supplemental enteral feeding support.

Grade 7: Severe impairment: severe dysfunction with significant aspiration or Inadequate oropharyngeal transit to esophagus, nothing by mouth, requires primary enteral feeding support.

For practical purposes, grade 5, 6–7 was graded as trace, and severe aspiration respectively. Severe aspiration required gastrostomy tube feeding to prevent aspiration pneumonia.

**Videofluoroscopic swallow study (VFSS)-Modified Barium Swallow**

It has been shown that contrast barium studies can be useful in characterizing swallowing abnormalities affecting patients with dysphagias in the oral and pharyngeal stages of the swallow (Martin-Harris et al., 2000).

The Modified Barium Swallow (MBS) examination, a videofluoroscopic procedure for assessing oropharyngeal swallowing, is the predominant method of oropharyngeal swallowing assessment. The MBS examination is used by the swallowing examination team, typically including the attending physician; consulting specialty physician, such as an otolaryngologist, neurologist, pulmonologist, or gastroenterologist; speech-language pathologist; and radiologist (Logemann, 1998).
Normative temporal swallowing measures have been established for the MBS examination in healthy young and elderly adults. These norms have been used to determine abnormal swallowing and to identify patients who are predisposed to aspiration pneumonia (Logemann, 1998).

Whilst some of the patients suffered from clinical globus symptoms and were found to have a low risk of serious pathology, a substantial number of patients had a serious newly identified problem, including those with cerebrovascular accidents, high spinal lesions or neurodegenerative disorders. These patients have a high risk of aspiration and we have shown that a MBS examination informs the crucial decision as to the most appropriate method of feeding, and the most appropriate consistency of food and drink. This can be achieved at low risk to both patient and operator.

**Scoring system for Penetration-Aspiration Scale**

**Category Score Description**

**Penetration**

1 Contrast does not enter airway
2 Contrast enters airway, remains above vocal folds, no residue
3 Contrast remains above vocal folds, visible residue remains
4 Contrast contacts vocal folds, no residue
5 Contrast contacts vocal folds, visible residue remains
**Aspiration**

6 Contrast passes through glottis, no subglottic residue visible

7 Contrast passes through glottis, visible subglottic residue despite patient response

8 Contrast passes through glottis, visible subglottic residue, no patient response *(Logemann, 1998).*

Videofluoroscopic swallow study (VFSS) has the ability to evaluate the oral pharyngeal and oesophageal phases of swallowing directly. Any abnormalities in bolus formation or timing of swallow, as well as velopharyngeal insufficiency, can be visualised. Premature spillage of the food bolus before the swallow, residue after the swallow, penetration into the airway, aspiration into the trachea with or without cough clearance, impaired passage into the oesophagus caused by cricopharyngeal achalasia, and regurgitation of swallowed food can all be seen. The examination can be tailored to provide consistencies similar to those the child is already eating at home, and optimal feeding position and food consistency can be assessed *(Martino et al., 2000).*

The VFSS is a videotaped or digitized fluoroscopic image, focusing on the oral, pharyngeal, laryngeal, and upper esophageal anatomy and swallow physiology. The patient is seated as upright as possible and should be viewed in the lateral and anteroposterior plane during the study. Radiopaque material, usually barium, is administered to the patient, with incremental increases in bolus volume as tolerated. The barium is usually mixed with liquid and food of varying consistencies in the process of a single study. Radiographic images are observed on
a monitor during the procedure, and should be simultaneously videorecorded or digitally recorded for further analysis (Martino et al., 2000).

The VFSS demonstrates anatomic structures and swallow physiology of the oral cavity, pharynx, larynx, and upper esophagus during deglutition. It identifies the disorders in movement patterns of the oropharyngeal, laryngeal, and esophageal structures, which may result in aspiration or inefficient swallowing. Compensatory and treatment strategies including head positioning and swallow maneuvers are tested during the VFSS to determine whether swallow efficiency is increased and/or if aspiration is reduced or eliminated (Palmer et al., 2000).

The VFSS is the gold standard for evaluating the mechanism of swallowing. VFSS is sometimes referred to as modified barium swallow. During this study, the patient will eat and drink foods mixed with barium while radiographic images are observed on a video monitor and recorded on videotape. This test is ideally performed jointly by physician and a speech-language pathologist. The study will demonstrate anatomic structures, the motions of these structures, and passage of the food through the oral cavity, pharynx and oesophagus. This test may also be used to test the effectiveness of compensatory manoeuvres that are used to improve swallowing (Rudolph, 2003).

Although feeding recommendations based on VFSS have been shown to decrease lower respiratory tract infections in acutely brain-injured adults with dysphagia (Schurr et al., 1999), findings in other studies have suggested that VFSS may have an unacceptable false-negative rate in predicting those who will progress to have aspiration pneumonia. Owing to the episodic nature of aspiration, a normal VFSS cannot entirely rule out aspiration of feeds. Generally, VFSS is a
standard evaluation for direct aspiration in patients in whom clinical examination has revealed abnormal swallowing (Kuhlemeier et al., 2003).

Disruption in temporal coordination of the critical physiologic components of swallowing, such as superior and anterior movement of the hyoid bone and larynx with consequent closure of the laryngeal vestibule, has been associated with aspiration during the MBS examination (Logemann, 1998).

It has been shown that contrast barium studies can be useful in characterizing swallowing abnormalities affecting patients with dysphagias in the oral and pharyngeal stages of the swallow. Plain chest radiographs and high-resolution computed tomography (HRCT) are utilised in the evaluation of patients suspected of aspiration. They are not, however, considered diagnostic tests for aspiration. Rather, they are useful indicators of lung injury which may be seen in a distribution characteristic of aspiration. They may also document progression or resolution of the disease process over time (Martin-Harris et al., 2000).

**Other less commonly used Radiological studies**

**Chest X-Ray**

Aspiration typically presents radiographically as hyperaeration, subsegmental or segmental infiltrates and peribronchial thickening. Bronchiectasis may also eventually be seen. The basilar and superior segments of lower lobes as well as posterior upper-lobe segments are the most significantly involved. Chest radiographs are not sufficiently sensitive to detect the subtle changes that occur in early lung injury.
**High Resolution Computerized Tomography (HRCT)**

High Resolution Computerized Tomography (HRCT) of the chest is known to be more sensitive than plain radiographs in the detection and definition of early airway and parenchymal disease in patients. In a patient with a suggestive history, the combination of airway and parenchymal findings in a distribution consistent with aspiration can be interpreted as evidence of lung injury caused by aspiration. HRCT can detect bronchiectasis, centrilobular opacities ("tree-in-bud"), air trapping and bronchial thickening (*Eastham et al., 2004*).

**Glottic Ultrasound**

Due to the invasive nature of FEES, a novel method of assessing vocal cord motion using glottic ultrasound is being developed for the evaluation of dysphagia. Further development of this technique may allow for the systematic study of pharyngeal and glottic reflexes that favour airway protection in infants in a non-invasive way (*Jadcherla et al., 2005*).

*Additional diagnostic testing that may be employed includes (Palmer et al., 2000):*

- **Esophagoscopy:** This test may be used to rule out neoplasm, particularly in patients who complain of thoracic dysphagia or odynophagia.
- **Esophageal manometry and pH probe studies:** These tests may be used when a motility disorder or gastric esophageal reflux disease is suspected.
- **Electromyography:** This test is indicated in patients with motor unit disorder such as polymyositis, myasthenia gravis, or amyotrophic lateral sclerosis.
- **Ultrasound imaging:** This testing has been used to a limited extent on infants to assess the oral phase of swallowing. The technique is limited to infants,
since teeth will interfere with the sound signal. This method will permit studying of infants during breast-feeding, since contrast media is not required.

Despite the use of multiple diagnostic techniques, characterising the presence or absence of aspiration, what a patient may be aspirating and under what circumstances this child might be aspirating is extremely challenging. This uncertainty is of great consequence given the outcome of unrecognised progressive lung injury and the invasiveness of definitive therapies. Since the 1990s, new diagnostic techniques have been introduced and significant advances in the understanding of dysphagia, gastro-oesophageal reflux and airway protective reflexes have been made. Nevertheless, many patients are still not adequately diagnosed or treated for aspiration until permanent lung damage and disability have occurred.

More research is needed to determine the accuracy of diagnostic methods and appropriateness of interventions. Given the complexity and heterogeneity of children affected, the variable and episodic nature of aspiration and the coexistence of various types of aspiration, conducting such research is exceedingly difficult. Currently, conducting a thorough clinical evaluation, using a multidisciplinary approach and utilising evidence from multiple diagnostic procedures is the best way to provide timely and appropriate care to patients with dysphagia and aspiration.
Rehabilitation of Deglutition after CLS

Rehabilitation is essential to ensure the Quality of Life

The amount of literature on dysphagia has assumed overwhelming proportions, even for specialists. One of the main issues is the need for a multidisciplinary approach to manage dysphagia, which must always take into consideration the underlying disorder. Defining the scope of practice in medical and rehabilitation settings allows a multidisciplinary approach with respect to each professional and targeting the needs of the patient (ASHA, 2001).

Cancers of the head and neck often have a profound impact on important quality-of-life functions, including swallowing. The successful treatment of these tumors may further impair these functions, and it is not unusual for patients to develop swallowing abnormalities and dysphagia after treatment.

The goal is to optimize the safety, efficiency, and effectiveness of the oropharyngeal swallow, to maintain adequate nutrition and hydration, and to improve oral hygiene. Enhanced quality of life, wherever possible, should direct management. This would be to maximize oral versus nonoral nutritional intake and hydration. The management plan is developed according to the clinical and instrumental assessment results. Compensatory strategies for increasing eating and swallowing efficiency, and for reducing the risk of aspiration, may involve modifying food and liquid consistencies and volumes, as well as altering the bolus presentation. Dietary modification is a common management approach. Patients vary in their ability to swallow thin and thick liquids, semi-solids and solids. The
consistency of the patient’s food should be individualized according to the findings from clinical testing (Chidester and Spangler, 1997).

**Multidisciplinary Approach**

As such, a multidisciplinary approach utilising the expertise of phoniaticrians, occupational therapists, dietitians, otolaryngologists, psychologists, neurologists, geneticists, surgeons, gastroenterologists and pulmonologists is often necessary.

Phoniatricians are an important part of the rehabilitation team. Special training in swallowing therapy is essential in working with conservation surgery patients. The phoniaticrian should review the barium swallow result preoperatively to determine whether a special swallowing study is necessary for delineating pre-existing swallowing problems. Special strategies are necessary to rehabilitate patients who have had hemiglottic or supraglottic laryngectomies. Involvement of the speech therapist also indicates to the patient that the surgeon is concerned about voice, communication, and swallowing needs.

**Assessment is the first step in Rehabilitation**

The development of specific competence in dysphagia makes the evaluation, by a phoniaticrian, an important step in the management of dysphagia. The treatment plan is designed according to clinical, non instrumental, and instrumental findings emerging from these evaluations. If the underlying disorder suggests a different diagnostic pathway, the specific phoniatic evaluation needs to be considered in every possible approach. The need of phoniaticrians for assessing dysphagia has been proposed for decades but only recently confirmed (ASHA, 2001).
The phoniatriacian must be involved both in the initial workup and design of
the treatment plan. Management must be patient oriented, considering that the
disability also involves the caregiver, so that the family, together with the clinician,
must identify the most appropriate goals to pursue, in line with patient choices
(Martino et al., 2000).

Anatomical variations resulting after Conservation Laryngeal Surgery
The most frequent anatomic situations which must be treated are:

1. An excessively posterior position of the cricoid ring in pexy with hyoid
   bone;
2. A reduced backwards pushing of the tongue base;
3. Stiffness, reduced motility or improper movements of the arythenoid/s, due
to injury of the recurrent laryngeal nerve or to a block of the crico-
arythenoid articulation;
4. An excessively anterior position of the residual epiglottis;
5. A small amount of mucosa covering the cricoid and/or the arythenoid/s
cartilage;
6. Reduced pharyngeal sensitivity, due to injury of the superior laryngeal
   nerve;
7. Scarring stenosis of the pyriform sinuses or excess mucosa in the neolarynx
   which interfere with the bolus progression;
8. In outcomes of supraglottic horizontal laryngectomy, surgical rehabilitation
   is rarely necessary, however, it can be advisable in the event of hypotrophic
vocal folds, reduced motility or paralysis of one or both vocal folds due to
recurrent laryngeal nerve paralysis or crico-arythenoid articulation block,
intervention to the enlarged tongue base (Ricci et al., 2007).
These situations can cause bolus inhalation, which is mostly intra-deglutitive, on account of an alteration in the pharyngeal phase of swallowing, but, sometimes, pre-deglutitive aspiration occurs, caused by an alteration in the oral phase or post-deglutitive aspiration, mostly due to an alteration in the oesophageal phase. The latter is due to spasm of the crico-pharyngeal sphincter, which prevents the entering of bolus into the oesophagus, with consequent stagnation in the piriform sinuses. This stagnation leads to a post-deglutitive inhalation of bolus if the glottic sphincter is not working well (Ricci et al., 2007).

**Crico-pharyngeal sphincter spasm**

The problem of the crico-pharyngeal sphincter spasm is not easy to solve, as gastric-oesophageal-pharyngeal reflux is often present in these patients; relaxation of the crico-pharyngeal muscle could be achieved by means of myotomy or a botulinum toxin injection into the crico-pharyngeal muscle, but the consequence is lack of protection of the lower airways from acid or alkaline reflux, as the neoglottis is not a valid protective sphincter. Myotomy or infiltration of the crico-pharyngeal muscle with botulinum toxin should be performed only in those patients for whom the presence of gastro-oesophageal reflux has been totally excluded. *Surgical approaches* for the treatment of dysphagia can be performed through an external or endoscopic approach (Marchese-Ragona et al., 2003; Ricci et al., 2007).

**Treatment plan**

Treatment of patients with swallowing disorders includes procedures to modify the physiology of swallowing or developmental deglutition patterns, with the aim of preventing aspiration even in the presence of anatomical modification of the effectors. Nutrition, hydration and drug administration are important outcomes.
The treatment plan includes procedures to increase the efficiency of the laryngeal sphincter, neuromuscular effectors (including interventions on hypo/hypersensitivity) and provide airway protection. Clinical evaluation may influence treatment outcomes, and these findings must be considered (Farneti & Consolmagno, 2007).

Treatment can be planned by the phoniatician together with other team members (dietician, occupational therapist, physiotherapist) and nurses, based on the initial evaluation. The phoniatician instructs trains and advises the patient and caregivers on swallowing techniques (manoeuvres and postures), optimising environmental conditions and behavioural patterns for safe deglutition. When possible, both patient and caregivers are actively involved in the treatment plan (Martino et al., 2000).

**Initial plan for feeding intervention**

For dysphagic patients, an initial plan for feeding intervention is usually developed during a bedside clinical evaluation, VFSS or FEES. Implementing compensatory strategies during these evaluations allows feedback to both physicians and caregivers regarding the effectiveness of the interventions. Compensatory strategies include positioning, pacing, thickening liquids, stimulating swallows and improving pharyngeal clearance. It is important to recognise that paediatric dysphagia is usually a mixed disorder caused by a combination of structural abnormalities, neurological conditions, cardiorespiratory problems, behavioural issues and inflammatory/metabolic disorders (Burklow et al., 1998).
**Low intensity versus High intensity interventions**

*Carnaby et al. in 2006* conducted a randomized, controlled trial to compare standard low-intensity and high-intensity behavioural interventions with usual care for dysphagia, standard low-intensity intervention, with frequency of three times weekly for up to a month; or standard high-intensity intervention and dietary prescription, with frequency of at least daily for up to a month. The primary outcome measurement was survival, free of an abnormal diet at six months.

Low-intensity interventions comprised swallowing compensation strategies, mainly environmental modifications, safe swallowing advice and appropriate dietary modification, under the direction of the speech pathologist. Standard high-intensity swallowing therapy consisted of direct swallowing exercises and appropriate dietary modification, under the direction of the study-speech pathologist (*Carnaby et al. in 2006*).

**Cerebral re-organization increases the swallowing recovery/pre-operative swallowing therapy**

It has been stressed that the physiology of deglutition changes significantly following conservation laryngeal surgeries (CLS): reorganization of neuromuscular events is required before functional deglutition can be regained. In fields other than deglutition it has been shown that the central nervous system can incur functional reorganization after a change in peripheral neuromuscular units. For example, many studies have stressed the use of new cortical and subcortical areas after the amputation of limbs. It is known that recovery of the swallowing function after a stroke depends on the functional reorganization of some cerebral areas, and it has
been reported more recently that, even after partial glossectomy, activity of the parietal and cerebellar cortex increases during deglutition (Mosier et al., 2005).

We may thus assume that, also after CLS, cerebral reorganization is necessary to restore functional deglutition. It is possible that the application of rehabilitative techniques before surgery may help to accelerate the cerebral reorganization needed for the recovery of swallowing. The use of functional magnetic resonance imaging (fMRI) in patients who have undergone partial laryngectomy will enable changes in cerebral organization to be verified, and may thus confirm the importance of preoperative rehabilitation (Mosier et al., 2005).

**Pre-operative swallowing therapy**

It has recently been reported that pre-treatment swallowing exercises improve the quality of life for patients with head and neck cancer undergoing radiation and chemoradiation. Although quality of life depends on many factors, one such factor may well be connected to the fact that muscle exercises improve swallowing. Similarly, we aimed to determine whether a pre-treatment approach can improve swallowing, thus reducing the duration of tube feeding. This preliminary study supports the hypothesis that pre-treatment rehabilitation impacts the management of head and neck cancer patients. Deglutition is usually impaired in patients with a tumour of the head and neck region; surgery and irradiation treatment can also both impair swallowing structures and mechanisms, making a swallowing rehabilitation program necessary (Mosier et al., in 2005).
Treatment Techniques

Treatment techniques include **compensatory strategies** (postural maneuvers) and **indirect therapy** (exercises to strengthen swallowing musculature). These techniques alter the physiology of the swallow to achieve improved efficiency or a safer swallow. There are specific strategies for improving airway protection, pharyngeal, and laryngeal and upper esophageal sphincter function. **Swallow maneuvers** place aspects of the pharyngeal swallow under voluntary control. For example, the Mendlesohn maneuver is designed to increase the extent and duration of laryngeal elevation in patients with reduced laryngeal movement. This in turn increases the duration and width of cricopharyngeal opening, another maneuver is the “super-supraglottic swallow,” which is designed to close the airway entrance before and during swallowing (Logemann, 1997).

The different strategies are used with patients who have reduced airway entrance closure, and are able to follow instructions. The findings from the clinical and instrumental examination will direct which strategies and exercises are most beneficial for a specific patient. Environmental strategies are often key in managing the dysphagia. These changes, which may include modifying the feeding environment or altering the feeding schedule, frequently improve nutritional intake. Education, training, and counselling of the patient and/or their caregiver is essential (Martino et al., 2000).

Effect of Swallowing therapy on the Gastrostomy tube

In head and neck cancer patients, swallowing therapy has been shown to reduce the need for gastrostomy tube in patients with postoperative aspiration. Following an intensive rehabilitation program, eight out of ten patients who
aspirated following laser surgery for supraglottic cancer were able to resume oral feeding. Swallowing therapy could also prevent aspiration or reduce the aspiration rate in patients with resection of the tongue base (Oeken et al., 2001).

**The rehabilitation include both compensatory & therapeutic procedures**

The rehabilitation techniques used after surgery to reactivate deglutition included both compensatory and therapeutic procedures. Compensatory procedures included compensatory postures (head rotated, head bent forward, head bent laterally), increase of sensory stimulus (use of cold bolus, acids, heat, and tactile stimuli), and changes in size and consistency of bolus. Therapeutic procedures entailed the patient’s being taught to adopt specific swallowing techniques (supraglottic swallowing technique, super-supraglottic swallowing technique, forced deglutition) and to do exercises to increase the range of movement (Logemann, 1985).

**The success of oral rehabilitation**

The success of oral rehabilitation after conservation surgery of the larynx depends on the amount of tissue removed and the overall condition of the patient. The lesion determines the extent of resection. Each patient has a different response to the surgery and recovers at his or her own pace. Therefore, starting oral rehabilitation at a predetermined time in every patient is not a good policy.

**Therapy for Swallowing and Feeding Disorders**

The goals of therapy include reducing aspiration, improving the ability to eat and swallow, and optimizing the nutritional status (Palmer et al., 2000). The choice of therapies is directed by the videoflouroscopic findings and the individual’s ability to comprehend and cooperate with the various strategies (Cook and Kahrilas, 1999).
The specific strategy that is utilized will depend on the dysfunction that is present. Swallowing therapy strategies may include (Agency for Health Care Research and Quality [AHRQ], formerly the Agency for Healthcare Policy and Research [AHCPR]):

- **Dietary modifications**: This technique may be used if the patient aspirates on only certain substances while swallowing.

- **Swallow therapies**: These therapies include the following:
  - Compensatory techniques: This technique teaches the patient postural manoeuvres to compensate for swallowing difficulty.
  - Indirect swallow therapy: This technique teaches the patient exercises to strengthen impaired or weakened muscles.
  - Direct swallow therapy: This technique teaches the patient exercises to perform during the swallowing process.

**Facilitatory postures**:

1. **Chin tuck/down**: The chin-down posture (also referred to as chin tuck or neck flexion) is useful for patients who have a delayed pharyngeal swallow, reduced tongue base retraction, or reduced laryngeal elevation. The patient is instructed to touch the chin to the neck while swallowing. This action pushes the anterior pharyngeal wall posteriorly, and the tongue base and epiglottis closer to the posterior pharyngeal wall, thereby narrowing the airway entrance. This posterior shift with the chin down posture improves airway protection so it is useful for patients with reduced laryngeal elevation or laryngeal vestibule closure. The vallecular space is also widened, giving a
potentially larger place for the bolus to set before the pharyngeal swallow is initiated (Welch et al., 1993).

2. **Head Back:** The head-back posture uses gravity to clear the bolus from the oral cavity in patients who have difficulty with oral transit of the bolus. If there is a question about adequate airway protection, the patient may be instructed in various voluntary airway protection maneuvers that will be discussed later. In appropriately selected patients, the head back posture has been shown to be 100% effective in transporting the bolus out of the oral cavity and into the pharynx (Logemann et al., 1994).

3. **Head Rotation:** Head rotation toward the weak or damaged side of the pharynx or larynx closes the damaged side so that the bolus flows down the more-nearly normal side. This posture is useful for patients with unilateral pharyngeal wall impairment or unilateral vocal fold weakness. Head rotation to the weaker side causes the bolus to lateralize away from the direction of rotation, and also increases upper esophageal sphincter (UES) opening diameter while causing a significant reduction in UES pressure (Tsukamoto, 2000).

4. **Lateral Head Tilt:** The lateral head tilt posture may be used for a patient who has both unilateral oral and pharyngeal impairment on the same side. The patient tilts the head to the stronger side so that gravity drains the bolus along the stronger side and avoids the weaker side (Logemann, 1998).

**Swallowing manoeuvres:**

1. **Supraglottic Swallow and Super-Supraglottic Swallow Maneuver:** The goal of the supraglottic and super-supraglottic swallow maneuvers, also referred to as voluntary airway closure techniques, is to close the vocal folds before and during the swallow in order to prevent aspiration. For the
supraglottic swallow, the patient is instructed to take a deep breath and hold it, swallow while continuing to hold the breath, and cough immediately after the swallow to expel any residue from the airway entrance.

The super-supraglottic swallow maneuver is designed to close the entrance to the airway voluntarily by tilting the arytenoids cartilage anteriorly to contact the base of the epiglottis before and during the swallow, and closing the false vocal folds tightly. The patient is instructed to “Inhale and hold your breath very tightly, bearing down. Keep holding your breath and bearing down while you swallow. Cough when you are finished.” Normal subjects also experience earlier cricopharyngeal opening, prolonged pharyngeal swallow, some degree of laryngeal valving before swallow, and change in extent of vertical laryngeal position before swallow. These changes in swallow physiology are more pronounced with the super-supraglottic maneuver (Ohmae et al., 1996).

2. Effortful Swallow Maneuver:
   - The effortful swallow is designed to increase tongue base retraction and pharyngeal pressure during the swallow in order to improve bolus clearance from the valleculae. The patient is instructed to squeeze hard with all their muscles as they swallow.
   - The effortful swallow is believed to increase pharyngeal pressures, thus pushing the bolus through the pharynx and cricopharyngeous, leaving less residue in the pharynx after the swallow.
   - Studies designed to measure oral, pharyngeal, and esophageal pressures during the effortful swallow provide conflicting information concerning the pressures generated with the procedure.
Effortful swallows performed by healthy normal adults are characterized by significantly higher oral pressures, diminished oral residue, longer laryngeal vestibule closure, hyoid excursion, and extent of hyoid elevation as well as longer pharyngeal pressure duration and upper esophageal sphincter (UES) relaxation duration.

The effortful swallow also has an effect on the esophageal phase of swallow with significantly increased peristaltic amplitudes within the distal smooth muscle region of the esophagus, possibly as a result of overflow effort from the maneuver (Lazarus et al., 2002).

3. Mendelsohn Maneuver:

- The Mendelsohn maneuver is a voluntary prolongation of laryngeal excursion at the midpoint of the swallow, intended to increase the extent and duration of laryngeal elevation and thereby increase the duration of cricopharyngeal opening (Mendelsohn & Martin, 1993).
- Patients are instructed to “Swallow normally. When you feel your voice box go up, grab it with your throat muscles and don’t let it go down. Hold it for 3 counts, and then let it go.”
- This maneuver can be practiced without food, and then food may be introduced with the maneuver once the patient has learned to perform it correctly.
- Videomanometric data confirm that use of the Mendelsohn maneuver in healthy adults results in increased duration of anterior-superior excursion of the larynx and hyoid and consequently prolonged cricopharyngeal opening by maintaining traction on the anterior sphincter wall as well as increased peak pharyngeal contraction and duration.
- Significantly longer bolus transit times occur as well, as would be expected when the subject is instructed to prolong laryngeal elevation (Lazarus et al., 1993, 2002).

4. **Tongue Hold:**
- The tongue hold maneuver is a technique for enhancing posterior pharyngeal wall movement. Contact between the tongue base and posterior pharyngeal wall is important for applying pressure on the bolus to aid in transport through the pharynx.
- Patients with head and neck cancer who have resection of the tongue base or radiation to the oropharynx may experience difficulty achieving tongue base to pharyngeal wall contact. The tongue hold maneuver was designed to augment posterior pharyngeal wall movement. The patient is instructed to protrude the tongue and hold it between the central incisors while swallowing.
- Young adult subjects demonstrate a significant increase in posterior pharyngeal wall bulging while performing this maneuver.
- Treated head and neck cancer patients produce higher pressure at the level of the tongue base and pharyngeal wall while performing this maneuver (Fujiu & Logemann, 1996).

**Bolus Size and Consistency Modifications**

Modification of bolus size and consistency may also be effective in eliminating aspiration in patients treated for head and neck cancer. These changes should be observed under fluoroscopy so the clinician can determine their impact on swallow physiology. For some patients, a larger volume bolus may be more effective at eliciting a more rapid pharyngeal swallow. Larger bolus volumes may
provide greater sensory input for the patient and increase awareness of the bolus in the oral cavity. However, patients who require multiple swallows to clear a single bolus will probably benefit from smaller bolus sizes in order to reduce residue and the risk of aspiration (Logemann, 1999).

Patients with oral stage problems such as reduced tongue range of motion, coordination, or strength will have greatest difficulty with thick foods. Patients with a delayed pharyngeal swallow or reduced airway closure may benefit from eliminating thin liquids or thickening them to a more viscous consistency. Those with swallowing disorders that result in retention of bolus in the pharynx (such as reduced tongue base retraction, reduced laryngeal elevation, and cricopharyngeal dysfunction) will have greater difficulty with thicker, higher viscosity foods.

Removal of specific food consistencies from the diet should be the last strategy to be contemplated. Elimination of certain food consistencies from the diet such as liquids can be difficult for the patient and may have an impact on the patient’s nutritional status. Bolus consistency modifications should be considered when postures and maneuvers are not feasible or are unsuccessful (Kuhlemeier et al., 2001).

Range of Motion Exercises

The normal range of motion of the lips, jaw, tongue, and larynx is often disrupted after treatment for cancer of the head and neck, as a result of either surgical resection or reconstruction of the structures or fibrosis induced by radiation. Range of motion (ROM) exercises are designed to improve the movement by extending the target structure in a desired direction until a strong
stretch is felt. The stretched position is held for one second and then the structure is relaxed (Waters et al., 2004).

It has been shown that postsurgical patients who performed ROM exercises in the first three months after surgery have significantly better swallowing function than those who do not perform these exercises. Range of motion exercises can be used for the lips, jaw, oral tongue, tongue base, larynx, and hyoid-related musculature. Although the optimal frequency and duration of ROM exercises is not yet determined, five to ten repetitions of each exercise for five to ten sessions per day are generally recommended (Waters et al., 2004).

**Jaw ROM**—Restricted mouth opening, often referred to as trismus, may result from surgical resection of the muscles of mastication, scarring after ablation of a portion of the mandible, or fibrosis of irradiated tissues. Current methods used to increase mouth opening include unassisted jaw ROM exercises, finger-assisted stretching exercises, stacked tongue depressors and mechanical assistance with a device such as Therabite (Cohen et al., 2005).

The jaw may be exercised by instructing the patient to open the mouth as widely as possible without causing pain and holding this position for two seconds. Next, move the jaw to the right side as far as possible, hold for two seconds, then relax; repeat the same movement to the left side. Finally the patient should move the jaw in a circular movement, relaxing after completing a full circle. Repeat the preceding exercises five to ten times per session, with the goal of five to ten sessions per day (Cohen et al., 2005).
Patients with very restricted oral aperture may assist jaw opening by stacking wooden tongue blades and inserting them between the teeth, adding additional tongue blades as range of motion increases. Mechanical devices such as the Therabite may provide assistance with mouth opening. Use of a mechanical device may increase jaw opening more than other methods of stretching; however research indicates that unassisted stretching exercises, use of stacked tongue depressors, and assistance by mechanical devices are all effective at increasing jaw opening in treated head and neck cancer patients (Cohen et al., 2005).

Tongue ROM Exercises

Scarring of the tongue after surgery may prevent sufficient range of motion to clear the bolus from the oral cavity; reconstruction procedures that tether the tongue anteriorly will negatively impact tongue base retraction. Fibrosis after radiotherapy will also reduce the tongue’s ability to move normally. Range of motion exercises may be used for the oral tongue and tongue base to improve movement.

Oral Tongue ROM Exercises

Tongue range of motion exercises for the oral tongue includes extension, lateralization, elevation, and retraction. Instruct the patient to stick out the tongue as far as possible past the lips without feeling pain, hold for 2 seconds, then relax. Next have the patient move the tongue to the right corner of the mouth, stretching as far as possible and hold for 2 seconds, then relax. Repeat this extension to the left side.

To elevate the front of the tongue, instruct the patient to lift the tip of the tongue and place it behind the top teeth along the alveolar ridge. Hold the position for 2 seconds and then relax. To elevate the back of the tongue, instruct the patient
to raise the tongue as if to produce /k/ or /g/; hold the position for 2 seconds, and then relax.

As the patient’s tongue elevation improves, extend the stretch by instructing the patient to lower the jaw as far as possible while holding the elevated tongue positions. For tongue retraction, instruct the patient to pull the tongue straight back in the mouth as far as it will go, hold for 2 seconds, then relax. Suggesting imagery of gargling or yawning may elicit greater retraction. Repeat the preceding exercises five to ten times (Veis et al., 2000).

**Bolus Manipulation Exercises**

Bolus manipulation exercises are a form of ROM exercise intended to enhance tongue movements required for chewing, bolus formation, and bolus transport. The exercises may be performed with a strip of gauze soaked in water or beverage, a flexible licorice stick or similar candy, or a small lollipop on a stick (Veis et al., 2000).

**Tongue Cupping**

This exercise is to practice holding a bolus in the oral cavity. Instruct the patient to take a piece of soaked gauze (or licorice stick, lollipop, etc.) and place it on the middle of the tongue, holding on to the other end outside the mouth. Hold the gauze against the roof of the mouth so that the tip of the tongue is sealed behind the alveolar ridge and the sides of the tongue are against the roof of the mouth near the molars (or gums if the patient has no teeth). Hold the position 5 seconds then relax. Repeat five to ten times (Logemann, 1998).
**Tongue Side to Side Movement**

This exercise is to practice moving the bolus back and forth onto the teeth or gums for chewing. Instruct the patient to take the gauze and place it on the tongue, holding the end of the gauze outside the mouth. Maneuver the gauze around in the mouth over to the left, then to the middle, then to the right, and back again. Repeat this circuit five to ten times. As the patient improves with lateralizing the gauze, they may be challenged by using a piece of loose hard candy (Logemann, 1998).

**Tongue Posterior Movement**

This exercise is to practice transporting the bolus through the oral cavity. Instruct the patient to take a piece of gauze and place it on the tongue, holding the other end outside the mouth. Move the gauze up and back with the tongue, as if attempting to swallow the gauze. If the gauze is soaked in a beverage, ask the patient to try to squeeze the liquid from the gauze and swallow (if it is safe for the patient to swallow) and to repeat this task five to ten times (Logemann, 1998).

**Tongue Base ROM Exercises**

Retraction of the tongue as far back as possible in the oral cavity will exercise the tongue base. Other exercises for tongue base range of motion include pretending to gargle and pretending to yawn, as discussed in the oral tongue ROM section. The gargle task has been demonstrated to elicit the most tongue base retraction when compared to pretending to yawn and pulling the tongue back as far as possible, although it is easy to try several techniques for the individual patient to determine what is most effective (Lazarus et al., 2002).
If reduced tongue base retraction is identified on MBS, it is wise to determine the effects of tongue pullback, yawn, and gargle imagery under fluoroscopy so that the most effective procedure may be integrated into the patient’s swallow therapy plan. Some maneuvers are also very effective at increasing tongue base ROM (Lazarus et al., 1993).

As discussed in the section on interventions during the MBS study, the Mendelsohn maneuver, Effortful Swallow, and Super-Supraglottic Swallow are not only effective at producing their intended target move but also result in increased tongue base retraction. Practicing these maneuvers with or without food as indicated for swallow safety may exercise the tongue base and enhance retraction (Lazarus et al., 2002).

Laryngeal ROM Exercises

Reduced laryngeal elevation is often reported in treated head and neck cancer patients, especially in those who have been irradiated. It has been demonstrated that reduced laryngeal elevation is significantly correlated with limitations in oral intake and diet during the first year after cancer treatment so improving laryngeal range of motion is a very important goal when formulating a swallow therapy plan for treated head and neck cancer patients (Pauloski et al., 2004).

Falsetto Voice

A falsetto voice exercise may be useful in improving laryngeal range of motion for elevation. During falsetto voice production, the larynx elevates nearly as much as it does during the swallow. The patient is asked to slide up the pitch scale as high as possible, into a high squeaky voice. At the top of the scale, the
patient should hold the note for several seconds with as much effort as possible. The clinician may manually assist the patient in raising the larynx if necessary, with the ultimate aim to eventually eliminate the manual assist (Pauloski, 2008).

Mendelsohn Maneuver

As previously discussed in the Maneuvers section, the Mendelsohn maneuver is a voluntary prolongation of laryngeal excursion at the midpoint of the swallow, intended to increase the extent and duration of laryngeal elevation and thereby increase the duration of cricopharyngeal opening. The Mendelsohn maneuver may be practiced with or without a bolus as dictated for safety (Kahrilas et al., 1991).

Shaker Exercise for Hyolaryngeal ROM

Another exercise that holds promise for patients with cricopharyngeal dysfunction is the Shaker Exercise. Because the suprahyoid muscle group responsible for displacement of the hyolaryngeal complex and opening of the UES appears responsive to external influences, a simple isometric/isokinetic head lift exercise aimed at these muscles was developed and tested (Shaker et al., 2002).

The Shaker Exercise consists of three repetitive 1-min sustained head raisings in the supine position, interrupted by a 1-min rest period. Sustained head-raising exercises are followed by 30 consecutive repetitions of head raisings in the same supine position. For both sustained and repetitive head raisings, subjects are instructed to raise the head high and forward enough to be able to see their toes without raising shoulders off the ground. The rationale for the exercise is to build strength in the suprahyoid musculature, thus enhancing hyoid and laryngeal
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elevation, which may permit longer and wider opening of the UES (Shaker et al., 2002).

The Shaker exercise has produced encouraging results in remedying or improving UES related dysphagia although its efficacy for treating dysphagia after treatment for head and neck cancer has not yet been demonstrated (Shaker et al., 2002).

Laryngeal Closure Exercises

Patients who have received surgical intervention or radiation to the larynx may have difficulty protecting the airway. Laryngeal closure exercises may be used to improve airway closure at the level of the true cords or higher at the vestibule. Vocal cord adduction exercises such as producing hard glottal attacks may be used to improve range of motion and enhance true cord closure (Logemann, 1998).

The Super-Supraglottic Swallow, discussed in the section on maneuvers, is designed to close the entrance to the airway voluntarily by tilting the arytenoid cartilage anteriorly to contact the base of the epiglottis before and during the swallow, and closing the false vocal folds tightly. The patient may practice this maneuver with or without food as needed for swallow safety in order to enhance closure of the laryngeal vestibule (Logemann, 1998).

Thermal/Tactile stimulation

Delayed triggering of the pharyngeal swallow has been observed in treated head and neck cancer patients. Thermal/tactile stimulation is designed to sensitize or stimulate the area of the oral cavity where the swallow reflex is thought to
trigger. The procedure consists of applying cold pressure to the base of the anterior faucial arches. The clinician may perform thermal/tactile stimulation on the patient and may instruct the patient how to perform the technique for home practice (Ali et al., 1996).

Instruct the patient to dip a laryngeal mirror into a cup of ice and ice water for 10 seconds. Firmly rub vertically up and down on the anterior faucial arch approximately 5 times on each side, making sure that the metal side of the mirror is against the tissue. Repeat on the other side if it is anatomically intact. Remove the mirror, pipette a few drops of water at the faucial arch and swallow. Repeat the procedure ten times (Rosenbek et al., 1991).

The effects of thermal/tactile stimulation have been investigated primarily in healthy adults and neurologically-impaired patients with delayed pharyngeal swallow, with some data indicating that thermal/tactile stimulation has no impact on the swallow, while other studies support the use of the technique for improving swallow physiology. There are currently no published data demonstrating the efficacy of thermal/tactile stimulation with treated head and neck cancer patients (Rosenbek et al., 1991).

Swallowing therapy has been proven to reduce the aspiration rate following various medical conditions like cerebrovascular accidents, brain injury, and degenerative neurologic diseases (Doggett et al., 2001). In head and neck cancer patients, swallowing therapy—begun early—has also proved effective in reducing episodes of aspiration and length of postoperative hospital stay (Oeken et al., 2001).
In order to restore per os nutrition, different exercises are practiced; suprasupraglottis swallowing, neck position technique, glottis knocking exercises, breathing control during swallowing, and tongue movements are among the most widely adopted techniques (De Vincentiis et al., 1998).

Review of the literature indicates that few clinical trials have been undertaken to assess the effects of treatment for dysphagia. Foley et al. in 2008 reported that the treatments included: texture-modified diets, general dysphagia therapy programs, non-oral (e.g., enteral) feeding, medication and physical and olfactory stimulation. Swallowing therapies and interventions in current practice appear to be based on clinical experience approaches that are physiologically based. The authors concluded that there is a need for high-quality research to identify effective dysphagia treatments.

Swallowing rehabilitation in patients, who have undergone partial laryngectomies, is aimed at close follow-up of those patients during the early postoperative period, supporting him/her in the two important functions, namely feeding and breathing. The larynx represents the main intersection between the air and the upper digestive pathways; therefore, in the first days after surgery, the main problems are: dyspnoea due to laryngeal obstruction (oedema), dysphagia due to lack of laryngo-pharyngeal coordination; and aspiration of food and saliva (Coscarelli et al., 2007).

**Electrical Stimulation for Dysphagia**

It appears the goal of the therapy is to stimulate and re-educate the neuromuscular pathways involved in swallowing. An electrical stimulation device, VitalStim was developed for the treatment of dysphagia. It was granted 510(k)
premarket approval by the U.S. Food and Drug Administration (FDA) in 2001. It is classified as a Class II device by the FDA, and the listed indication for use is: muscle re-education by application of external stimulation to the muscles necessary for pharyngeal contraction (Hayes, 2006).

Leelamanit et al. (2002) conducted a prospective study to test the hypothesis that synchronous contraction of the thyrohyoid muscle by electrical stimulation during swallowing would improve dysphagia. Twenty-three patients with moderate-to-severe degree of dysphagia resulting from reduced laryngeal elevation were treated with electrical stimulation. It was noted that of the 23 patients, 20 showed improvement. Six patients who had achieved improved swallow criteria relapsed at 2–9 months.

The National Institute of Health-Swallowing Safety Scale (NIH-SSS) was utilized for the video-fluoroscopic recordings of swallows. Significant laryngeal and hyoid descent occurred with stimulation at rest. Significant reductions in both the larynx and hyoid bone peak elevation occurred during stimulated swallows. The stimulated swallows were also judged to be less safe than non-stimulated swallows using the NIH-SSS. The authors noted that since surface electrical stimulation reduces hyo-laryngeal elevation during swallowing in normal volunteers, the findings propose that surface electrical stimulation will reduce elevation during swallowing therapy for dysphagia (Ludlow et al., 2007).

The American College of Chest Physicians (ACCP) guidelines regarding cough and aspiration of food and liquids due to oral-pharyngeal dysphagia include a recommendation regarding electrical stimulation “for patients with muscular weakness during swallowing, muscle strength training, with or without
electromyographic biofeedback, and electrical stimulation treatment of the swallowing musculature are promising techniques, but cannot be recommended at this time until further work in larger populations is performed” (Smith Hammond and Goldstein, 2006).

**Surgical rehabilitation of dysphagia**

Surgical rehabilitation of dysphagia in patients who have undergone partial laryngectomy is aimed at improving the sphincteric action of the larynx, the anatomy and physiology of which are impaired. The interventions indicated for this purpose can be performed either with an external or endoscopic approach. The Authors present early results of their experience employing injection laryngoplasty with autologous fat, bovine collagen (Zyplast®, McGhan Medical Corporation, Fremont, CA, USA) and PDMS (Vox Implants®, Uroplasty Inc, Minnetonka, MN, USA), performed by means of fiberendoscopy, under local anaesthesia, and microlaryngoscopy, under general anaesthesia (Ricci et al., 2007).

Surgical rehabilitation of dysphagia, after partial laryngectomy, is aimed at improving the sphincteric action of the larynx, the anatomy and physiology of which is completely deranged due to oncologic surgery. After surgical treatment of supraglottic horizontal laryngectomy, swallowing usually recovers spontaneously and completely, while after surgical treatment such as reconstructive laryngectomies with cricohyoidoepiglottotopexy, cricohyoidopexy, tracheohyoidoepiglottotopexy or tracheohyoidopexy “microinhalations” are unavoidable which decrease with time and particularly with logopaedic rehabilitation. But if, after several weeks, “macroinhalations” are present, which can cause bronchopneumonia *ab ingestis*, then surgical rehabilitation is indicated, in order to avoid gastric tube (percutaneous endoscopic gastrostomy - PEG) or total laryngectomy.
**Surgical techniques**

**External surgery techniques:**
- revision of the cricohyoidopexy with a more anterior positioning of the cricoid, in order that the tongue base is pushed back to protect the airways;
- fixing of the residual epiglottis in a backwards position;
- fixing of the still arythnoid in an anterior and medial position;
- creation of mucosa flaps covering the cricoid.

**Endoscopic approaches:**
1) removal of the lesions which interfere with bolus progression, proposed by Piemonte in 1989.
- opening of the pyriform sinus with lysis of retractions or scarring adherences of the ari-epiglottic wall to the lateral wall of the hypopharynx;
- removal of floating muscle-mucosa strips to restore correct travelling of the pharyngeal muscular wave;
- reduction of arythenoid oedema or removal of supra-arythenoideal mucosa;
2) techniques for reducing the glottic or neoglottic insufficiency, which causes food inhalation. These refer to injection laryngoplasty procedures, which can be performed:
- by means of microlaryngoscopy under general anaesthesia, with injection of reabsorbable or non-reabsorbable material;
- by means of fiberendoscopy under local anaesthesia, with injection of reabsorbable or non-reabsorbable materials.

*(Remacle et al., 1990; Ricci et al., 2007)*
The injection points are:

– arythenoid/s, in order to create a “valve” effect and a contact with the tongue base or with the residual epiglottis; superior face of the cricoid ring, in order to recreate the medial wall of the pyriform sinus;
– tongue base, in order to reduce the “slide” effect that occurs when the tongue base is in an exceptionally anterior position.

Following supraglottic horizontal laryngectomy, the injection points are the middle third of the vocal fold in cases of atrophic vocal folds and the posterior third of the vocal fold in cases of unilateral laryngeal paralysis; in cases of bilateral paralysis of the vocal folds injection laryngoplasty is not recommended, while the recommended surgical procedures are those improving breathing without having a negative effect upon swallowing (Ricci et al., 2007).

The choice of the most appropriate injection to perform is taken after a careful evaluation of the recorded fiberendoscopical examination during phonation and swallowing; in patients submitted to tracheostomy, laryngeal fiberendoscopy is performed also “from the bottom” through the tracheostomy, with a detailed display of the site and the amount of the eventual intra-deglutitive inhalation of food.

**Dynamic Assessment and therapy**

The advantages of the fiberendoscopic, compared to the microlaryngoscopic, procedure are:

– “functional” display of the operative field, with the possibility to check the effect of laryngoplasty on swallowing and phonation;
– chance to perform the intervention even when tracheostomy has already been closed.
On the other hand, disadvantages are:
– need of collaboration on the part of the patient as swallowing must not be effected during the injection;
– a less precise injection, as the needle cannot remain inserted for a long time, since slight movements of the patient, the needle or the endoscope can enlarge the breach or lacerate the mucosa, with consequent leakage of material into the airways (Presutti & Bergamini et al. in 2010).

Swallowing rehabilitation, in patients who have undergone partial laryngectomy, is aimed at close follow-up of the patient during the early post-operative period, supporting him/her in the 2 important functions, namely feeding and breathing. The patient will learn to use the new larynx, with decreased sensitivity and mobility due to the surgery. The larynx represents the main intersection between the air and upper digestive pathways and, in the first days after surgery, the main problems are: 1) dyspnoea due to larynx obstruction (oedema); 2) dysphagia due to lack of laryngo-pharyngeal coordination; 3) aspiration of saliva or food. For these problems, the presence of a tracheotomy tube is essential since it guarantees a normal air exchange and a mechanical blockage to aspiration. At the end of rehabilitation, the patient should be able to eat alone and to use a social effective voice (Ludlow et al., 2007).

**The discharge plan**

At the end of treatment, or when particular conditions arise (i.e., hospital discharge), the patient is given a series of goals to pursue in other settings or at home. The discharge plan identifies the goals and professionals involved (family physician, caregivers, home-care nurses). Plans are provided for patients identified by screening, bedside and/or instrumental assessment, submitted or not submitted to treatment. Patients and caregivers must be trained to identify ominous signs and
symptoms of complications: cough, gurgling, pooling, etc. The availability of timely consultations with the Centre or urgent phoniatrie-logopedic evaluations, in liaison with different professionals, represents an added benefit, having an impact on quality of service and patient satisfaction (Martino et al., 2000).