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Deglutition after Supracricoid Laryngectomy: Compensatory Mechanisms and Sequelae

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Abstract. This study is based on the videofluorographic exploration of deglutition in 14 patients who were treated by supracricoid laryngectomy. The choice of this population rests on two criteria: a 1-year postoperative delay, and absence of residual deglutition disorders elicited by patient history. Asymptomatic aspiration was seen in 6 cases. In the cricohyoidoepiglottopexies (CHEP), aspiration occurred uniquely in patients who did not recuperate satisfactorily from epiglottic dynamics. The deglutition sequelae are less invalidating relative to the cricohyoidopexies (CHP), with a possible recuperation of the dynamic sequence of the pharyngeal swallow. On the other hand, in the CHP, a complete reorganization of the stepwise sequence of the different neuromuscular events is necessary.

Key words: Postsurgical cancer — Supracricoid laryngectomy — Deglutition — Deglutition disorders.

Supracricoid laryngectomies classically regroup two types of interventions: the cricohyoidoepiglottopexy (CHEP) [1,2], and the cricohyoidopexy (CHP) [3,4]. Though similar in their surgical concept, they differ in their consequences on deglutition. Their postoperative management is now well codified [5–7], but functional failures persist.

The aim of this study was to describe the long-term, infraclinic deglutition modifications induced by these interventions. These data allow for a better analysis of the poor functional results that the therapist may confront.

Moreover, with postoperative videofluorographic studies of swallowing being rare [7,8], this study gives a morphologic and dynamic description of the pharyngolaryngeal modifications.

For this study, we have analyzed 14 patients of the 146 operated on in our department since 1974.

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Materials and Methods

Population and Surgical Procedure

The population studied consisted of 14 males with a mean age of 55 years (38–69 years), who underwent 11 CHEP and 3 CHP. These interventions have their own respective indications [2,4,10,11]. The cancers were localized in the glottis (11 cases) or in the supraglottis (3 cases), and were staged T1 in 11 cases and T2 in 3 cases according to the 1992 American Joint Committee on Cancer Staging criteria. The tumor status was 3 T1a, 8 T1b, 3 T2. All patients were N0 and MO. Postoperative follow-up was at least 1 year (12–96 months).

Regarding the therapeutic protocol, supracricoid laryngectomy was the intervention of choice in all cases. In 6 cases, this was associated with a radical neck dissection. No complementary radiotherapy was deemed necessary.

The surgical technique corresponded to that described by Piquet [1,2,11] for the CHEP [1,2,9,10], and that of Labayle [3,4,9,11] for the CHP. The two arytenoids were conserved in all CHP, as well as in four CHEP interventions.

The mean duration for postoperative decannulation was 9 days, and for nasogastric tube removal, 20 days.

Methods

Data for this study were collected during follow-up consultations. History and videofluorographic examination served for patient selection. All patients claimed to have recovered "normal" swallowing. Their weight was stable, and no pulmonary symptoms were elicited. Videolaryngostroboscopic examination appreciated neoglottic dynamics during phonation. All patients presented complete neoglottic closure, as described in the literature [6,12,13].

Videofluorographic swallowing was studied and interpreted according to the protocol described by Logemann [14]. Frame by frame analysis of the recordings was realized with a UMATIC Sony SP VO 9600P recorder. The examination was practiced using three incidences:

face, profile, and three-fourths. Due to the risk of aspiration (material theoretically reserved for airway opacification), the contrast material used was not barium but a derivation of lopydol (Hytrast). The bolus was 8 ml of liquid presented in a spoon.

Statistical Analysis

The ADIMEP DM90 program (Toulouse, France) was used for statistical analysis. Due to the small patient population, we used nonparametric tests (Mann-Whitney U test) and the test of direct calculation of probability by the hypergeometric law.

Results

Morphologic Modifications

In the profile incidence, the following anatomic landmarks were modified:

1. A verticalization of the hyoid bone in all cases (oblique axis superiorly and posteriorly defining a 45° angle relative to the horizontal plane)
2. A cricoid cartilage visible in 9 cases
3. A distance between the hyoid bone and the cricoid cartilage superior to 1 vertebra in 5 cases
4. A projection of the hyoid bone at the level of the fifth vertebra in 8 cases, and between the third and fourth vertebra in the remaining 6 cases, 2 of which were the CHP.

After the CHEP, the valleculae and the free edge of the epiglottis were well defined. The arytenoids were projected above the level of the hyoid body, generally at the mid-epiglottic level.

Dynamic Modifications

Cricohyoidoepiglottopexy

The recuperation of the different events of the pharyngeal phase of swallowing is frequent. Table 1 shows the frequency of the different recuperation defects. The absence of a complete backward-tilting epiglottis is noted in 4 cases. Posterior movement of the tongue base is reduced in 2 cases; this movement is increased in five cases (large contact with the pharyngeal wall), and seems to be normal in 4 cases. In 1 case only, delayed triggering of pharyngeal swallow was observed. Premature closure of the upper esophageal sphincter (UES) was noted in 1 case, without consequence on the airway protection mechanism. Pharyngeal phase duration was increased (>2 sec) in 2 cases; in one of these, this increase was associated with an UES opening dysfunction. In the second patient, the disorder was associated with a decrease in pharyngeal wall contraction, as well as a decrease in posterior movement of the tongue base, with aspiration.

Table 1. Dynamic modifications and bolus evolution

Recuperation defects	Case frequency	
	CHEP	CHP
Reduced movement of back tongue	4	3
Delayed triggering of pharyngeal swallow	1	0
Reduced pharyngeal wall contraction	2	0
Reduced posterior motion of the tongue base	2	3
Faulty backward-tilting epiglottis	4	–
Reduced anterior laryngeal movement	3	3
Reduced laryngeal elevation	3	3
UES opening dysfunction	1	1
Stasis in hypopharynx	3	0
Aspiration	4	2
Increased oropharyngeal transit	2	1

Neoglottic closure was obtained in all cases by a forward movement of the one or two remaining arytenoids coming in contact with the laryngeal wall of the epiglottis.

Cricohyoidopexy

The dynamics of the pharyngeal phase was modified. In all cases, neoglottic closure preceded the triggering of pharyngeal swallow. This closure begins at the start of the oral swallow, with a posterior motion of the back tongue (as defined by Logemann [14]) and the tongue base joining the arytenoids, which realize a forward and inward rotation movement. The neolarynx is anteriorly and superiorly displaced, ascending less than one vertebra. Despite this limited rise, the neolarynx is situated high (C3-C4) due to morphologic modifications.

The pharyngeal swallow begins normally in all cases, but the bolus is not propulsed by the tongue, which conserves its position to assure neoglottic closure. The bolus enters the oropharynx by the prolongation of the front to back movement of the tongue in the oral cavity. The bolus thus passes between the soft palate above and the back of the tongue, then the arytenoid below. The increased pharyngeal contraction takes charge of the bolus early in its course, guiding it toward the hypopharynx. The posterior motion of the tongue base is reduced. This movement occurs tardively, when the tail of the bolus is at the retrocricoid level. The arytenoids back up with the tongue base and the neoglottic closure is thus maintained. Premature closure of the UES was noted in 1 case, with an increase in the duration of the pharyngeal swallow, but without consequence on airway protection.

Evolution of the Bolus (Table 1)

Cricohyoidoepiglottopexy

Aspiration of a small volume was seen in 4 patients. In 2, aspiration occurred during pharyngeal swallow, and in

the other 2, it occurred after this phase. In 3 patients, the cough reflex was either diminished or abolished at the neolaryngeal or tracheal level.

In studying the mechanism of these aspirations, a faulty synchronization between the posterior motion of the tongue base and the complete neoglottic closure was noted in 2 cases. The dynamic sequence was terminated, with the tail of the bolus already at the UES, with a small quantity penetrating the neoglottis. In the 2 other cases, an insufficient posterior motion of the tongue base was found, leading to faulty protection of the superior region of the neolarynx. The contrast material penetrated between the laryngeal face of the epiglottis and the one or two remaining arytenoids, and was then aspirated into the trachea during inspiration. These aspiration episodes occur uniquely for liquids, and are of little quantity.

In 3 cases, on frontal view, the formation of a recess at each side of the neoglottis was observed. These were filled during swallowing, defining a hypopharyngeal stasis, with rapid emptying during secondary swallowing, without provoking aspiration by overflow.

Statistical analysis, searching for a correlation between the onset of aspirations, and the different events during the pharyngeal swallow resulted in a statistically significant relation with the absence of recuperation of a functional epiglottis ($p < 0.01$). An increase in aspiration frequency without a statistically significant relationship was found with a reduced hyoid bone elevation, a reduced anterior neolaryngeal movement, and a reduced posterior motion of the tongue base. No relationship was found with the number of remaining arytenoids.

Cricohyoidopexy

Two patients presented aspirations. In 1, this occurred during and in the second it appeared after the pharyngeal swallow. The cough reflex was diminished or absent in the 2 cases. In the first case, the mechanism of these aspirations is neoglottic opening during bolus propulsion with the back and the base of the tongue being deformed by participation in propulsing the bolus, thus leading to a faulty contact with the arytenoids. In the second case, contrast material stasis between the tongue base and the arytenoids penetrates into the neoglottis during inspiration.

Mechanisms of Compensation

Cricohyoidoepiglottopexy

The normal sequence of the different neuromuscular events is negligeably modified in the CHEP. The compensatory mechanisms depend on the adequate neoglottic closure, that which is defined during phonation [6,8]. It is the inward and forward movement of the arytenoids coming into contact with the epiglottis, which replaces the normal glottic closure level. This movement leads, at the same time, to a neovestibular occlusion. Neolarynx closure is completed by epiglottic folding and posterior tongue base movement, with the increase of the latter permitting the compensation of faulty epiglottic mobility secondary to the pexy. Three occlusion planes are thus reconstituted: a neoglottic closure, a backward-tilting epiglottis, and a tongue base covering (Fig. 1).

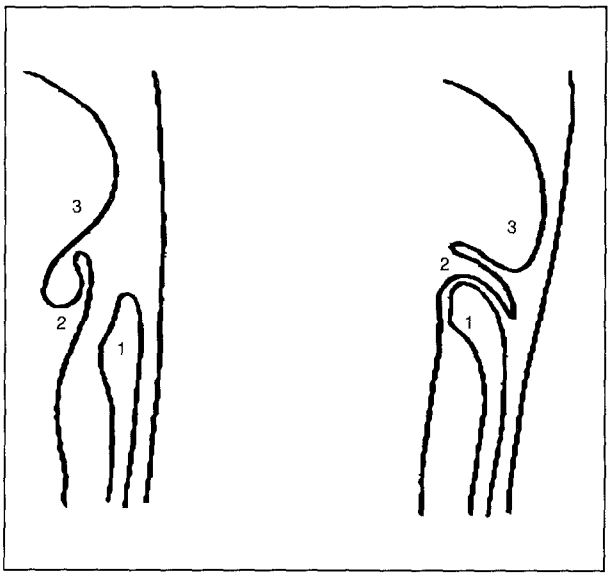

Fig. 1. Closure during deglutition after cricohyoidoepiglottopexy. 1 = Arytenoid, 2 = epiglottis, 3 = tongue base.

Cricohyoidopexy

Concerning upper airway protection, the necessity of maintaining the back tongue, as well as the tongue base, against the arytenoids for an entire neoglottic closure completely modifies the swallowing mechanism.

As for bolus transport, the sequelae are of little importance. The following modifications are related to the compensatory mechanisms of airway protection: (1) an increase in the anterior to posterior tongue movement during the first phase, in order to compensate for the diminished role of the posterior tongue in the propulsion of the bolus; and (2) an increase in pharyngeal wall contraction, which takes up the bolus earlier, compensating for the loss of the backward tongue base movement.

This type of intervention reduces the occlusion at only one level (Fig. 2), and necessitates a complete reorganization of the stepwise sequence of the different neuromuscular events.

Discussion

The originality of this work is in the study of the long-term swallowing mechanisms after supracricoid laryngectomy.

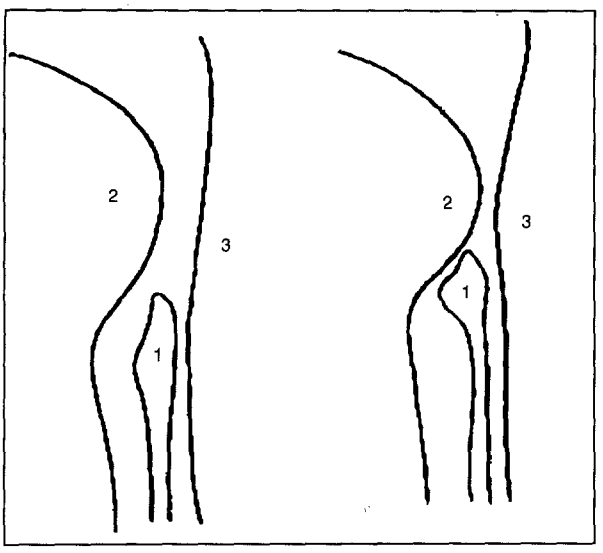

Fig. 2. Closure during deglutition after cricohyoidopexy. 1 = Arytenoid, 2 = tongue base, 3 = posterior pharyngeal wall.

Review of the literature is poor, notably in the domain of radiologic data [7,8].

The long-term morphologic modifications, when confronted with those seen in the immediate postoperative period [7], favor an increasing separation between the hyoid bone and the cricoid cartilage, with a lowering of the neolarynx over time. This separation has been described postoperatively [7] as a sign of suture rupture (diastasis >2 cm). This phenomenon is observed after a minimum delay of 1 year, whereas no swallowing difficulties are described by the patients during this time. Thus, the probability of a pexy rupture (due to a technical error or other causes), is low, and we hypothesize that the separation is probably due to forces exercised on the neolarynx (upward traction, tracheal anchoring). This is equally true for hyoid bone verticalization, which appears in the immediate postoperative period (horizontalization being a sign of suture rupture). We have observed a similar separation of anatomic structures after the pexy in supraglottic laryngectomies [15].

Few modifications are found in the bolus transport. The paraneoglottic recesses have already been described in the literature [7,16]. This seems secondary to inferior constrictor disinsertion from the thyroid cartilage, and may be responsible for aspiration by postswallowing overflow. In our study, they are observed in 4 cases, and are not the origin of aspiration in these asymptomatic patients. In order to avoid their formation, Laccoureye et al. [16] propose the reattachment of the inferior constrictors, as well as the external perichondrium of the thyroid cartilage wing, to the pexy. Thus, aspiration induced by these recesses is not systematic. It is equally possible that the aspirations disappear after functional recuperation. The interest of systematic anchoring of the inferior constrictors has not as yet been demonstrated as much as it seems of interest. Pharyngeal wall contraction and UES opening deficits are less frequent (2 patients). These are probably favored by the disinsertion of the pharyngeal constrictor musculature, as well as by the dysynchronization of neuromuscular events.

The dynamic modifications are different between CHEP and CHP. For the CHEP, the linking of the different neuromuscular events is little modified. As for airway protection, 4 of the 11 patients presented aspiration episodes because of a faulty closure of the superior portion of the neolarynx, and by the diminished cough reflex. These sequelae are secondary to the loss of the sequential laryngeal closure mechanisms which expulse the particles into the endolarynx. The absence of recuperation of the cough reflex at the neolaryngeal level is linked to the removal of a large region of the mucosa which normally intervenes in the sensory system of protection [7]. On the other hand, the decrease of the reflex at the tracheal level remains unexplained. These are symptomatically of little importance, but they pose the problem of chronic foreign body penetration into the bronchotracheal tree.

In the CHP, the mechanism of the first two phases of swallowing differs completely from the norm. Regarding upper airway protection, 2 patients presented aspiration episodes which occurred because of faulty neoglottic closure, most often secondary to a poor adaptation of lingual dynamics. Even if neoglottic closure is maintained during the pharyngeal swallow, the persistant stasis between the arytenoids and the lingual base may be aspirated after swallowing.

Different surgical procedures have been described to counteract the failures of these interventions [7,8,16–18] e.g., collagen injection into the ary-epiglottic fold or into the tongue base, increasing the height of the mucosal covering.

Before any surgical treatment of these functional failures, Traissac et al. [7] obtain radiological landmarks, allowing for visualization of the dynamics of the neuromuscular events.

Analysis of the sequelae by our method confirms that (1) an adequate study of the dynamics of the upper airway and digestive intersection is indispensable for determining the cause of functional failures, as well as for choosing optimal management; and (2) the readaptation delay should be taken into account. This study emphasizes the role of the epiglottis.

Described as a shield, its directional role is sufficient for the bolus to avoid the larynx. After CHEP, this role seems insufficient for assuring airway protection. Complete epiglottic backward tilting leads to an inversion of its position (Fig. 1), which is necessary for a definitive disappearance of aspiration. According to Ekberg and

Sigurjonsson [19], this inverted position is normally assured by (1) the combined pressure of the posterior tongue base movement and the laryngeal elevation; (2) the contraction of the thyroepiglottic muscles; and (3) the pressure of the bolus. Moreover, this position participates in the sequential closure of the larynx [20]. Thus, the recuperation of a proper epiglottic movement, as well as the increase of backward tongue base movement, are of major importance for readaptation.

Ekberg and Nylander [21] have shown that 8% of patients with no swallowing deficits present with epiglottic mobility anomalies. One may hypothesize that the absence of functional recuperation corresponds to abnormalities existing prior to the intervention. Moreover, early neoglottic closure approaches the "closed" type of pharyngeal swallowing described by Curtis and Cruess [22] in healthy subjects. This phenomenon, considered by certain authors as a physiologic compensatory mechanism, may explain the variations in recuperation delay in patients who have undergone surgery. Only a prospective study containing a systematic preoperative workup will offer an explanation for these patients.

Conclusion

Swallowing mechanisms are different after these two types of supracricoid laryngectomies. Few sequelae are observed after a CHEP and are more frequent after a CHP, especially in the domain of airway protection. Readaptation after this intervention necessitates a complete modification of the pharyngeal swallow mechanism.

Precise analysis of swallowing mechanisms will ultimately allow for better management of these postoperative complications.

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