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# **Oncological Outcomes of Supratracheal Laryngectomy: A Critical Analysis**

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**Key words:** Open partial laryngectomy, supratracheal partial laryngectomy, laryngeal function sparing protocol, laryngeal cancer, aspiration pneumonia

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### **Author Contributions**

Giuseppe Rizzotto, surgeon who performed surgical procedures, study conception and design, final approval of the version to be published; Erika Crosetti, study conception and design, drafting the article, final approval of the version to be published; Marco Lucioni, surgeon who performed surgical procedures, study conception and design; Andy Bertolin, study conception and design; Valentina Monticone, data collection; Andrea E Sprio, data analysis, statistical analysis, drafting the article; Giovanni N Berta, data analysis, drafting the article, final approval of the version to be published; Giovanni Succo, surgeon who performed surgical procedures, study conception and design, drafting the article, final approval of the version to be published.

## **Abstract**

*Background.* Laryngeal cancer management should pursue function-sparing therapeutic options. Even though demolitive surgery provides better control of disease at intermediate-advanced stages when compared to chemoradiotherapy, it does not preserve laryngeal function. Supratracheal partial laryngectomy (STPL) has been described as a function-sparing surgical technique for laryngeal cancer with sub-glottic extension.

*Methods.* In this retrospective study, we analyzed the clinical outcomes of 115 patients who underwent STPL.

*Results.* At 5 years: overall survival (OS), disease-free survival (DFS) and loco-regional control (LRC) rates were 78.9%, 68.5% and 69.6%, respectively; DFS and LRC prevalences were greatly affected by pT4a classification (49.0% and 51.4%, respectively); laryngeal function preservation (LFP) was maintained in 78.3% of patients despite being affected by pT4a classification (59.3%) and age  $\geq 65$  (64.6%).

*Conclusions.* For cases with glottic tumors and with sub-glottic extension, the choice of STPL vs chemoradiotherapy can be considered to be effective in terms of prognostic and functional results.

## Introduction

Laryngeal squamous cell carcinoma (LSCC) represents 2% to 5% of all diagnosed tumors worldwide with a peak incidence in men aged between 55 and 65 years.<sup>1</sup> Therapeutic approaches developed in the twentieth century have significantly improved overall survival from this type of cancer, however, poor prognosis and loss of functionality of the larynx still characterize the disease in its advanced stage.<sup>2-4</sup> Treatment includes surgery alone or in combination with chemo- and/or radiotherapy, and management of laryngeal cancer varies depending on localization and staging at diagnosis. Early stages (I and II) are treated with unimodal therapy, which can include surgery or radiotherapy, while for the advanced stages (III and IV), chemo-radiotherapy and demolitive surgery are considered to be the gold standard therapeutic approach.<sup>5-7</sup> A third alternative, though not fully accepted worldwide, is represented by function-sparing surgical protocols with open partial laryngectomy. Despite encouraging oncological results, the main criticisms of this approach are the criteria for patient selection and functional results, the latter being not easily repeatable.<sup>8-11</sup>

To preserve laryngeal function surgically in intermediate and advanced stages, different types of open partial laryngectomy have been proposed beginning with the first supratracheal open partial laryngectomy (STPL) described by Italo Serafini in 1972.<sup>12</sup> In 2006, our group reported a modified functional version, in which at least one functioning cricoarytenoid unit was spared (i.e. half of the posterior cricoid plate, with the corresponding arytenoid and the intact inferior laryngeal nerve on the same side).<sup>13</sup>

Nowadays, STPL is based on resection of the whole glottic and subglottic sites and of the thyroid cartilage, sparing both or at least one functioning cricoarytenoid unit. Inferiorly, the limit of resection encompasses the cricoid ring sparing the first tracheal ring. The various types of STPLs, also identified by the type of laryngeal resynthesis as tracheo-hyoid-

epiglottopexy (STPL-THEP) or tracheo-hyoid-pexy (STPL-THP), differ in the amount of supraglottis resected and in the lateral extent, if any, to include one cricoarytenoid unit. Extending the inferior limit of resection to include a large part of the cricoid cartilage, STPLs expanded the indications with respect to open partial supracricoid laryngectomies (SCPL).<sup>14, 15</sup> Some “problematic” glottic cT3 (i.e. sub-glottic extension and cricoarytenoid joint invasion) and some supraglottic cT3 (i.e. large transglottic extension) result, hence are manageable with STPLs; these interventions have shown promising oncological and functional results.<sup>13</sup>

In this study, we present a multicentric retrospective outcome analysis of 115 patients with supraglottic/glottic LSCC managed by STPL-THEP or STPL-THP over a 10-year period, during which organ-preservation protocols with chemoradiotherapy or total laryngectomy were applied as conventional therapeutic options for these types of locally advanced tumor.<sup>5, 7, 16</sup>

## **Materials and methods**

### *Patients*

All patients were from the Hospital of Vittorio Veneto, Treviso or the Martini Hospital of Turin. Selection was based on the superficial and depth extent of the tumor. During the 3 weeks preceding surgery, all patients underwent: flexible videolaryngoscopy; intraoperative rigid endoscopy with 0°/angled telescopes and biopsy during microlaryngoscopy; laryngeal and neck CT-scan or MRI; bronchoscopy and esophagoscopy to rule out synchronous tumors; chest X-ray or CT-scan to exclude lung tumors or distant metastases; assessment of bronchopulmonary function and of comorbidities for at-risk patients; and nutritional evaluation.

Inclusion criteria were histological diagnosis of glottic or supraglottic LSCC, with Karnofsky index<sup>17</sup> higher than 80.

Exclusion criteria were severe diabetes mellitus, severe bronchopulmonary chronic obstructive disease and severe cardiac disease. Advanced age, an important cut-off for relative surgical indication, has not been considered, in itself, as an exclusion criterion.<sup>18</sup>

### *Surgery*

After informed consent had been obtained, 120 patients were selected to undergo STPLs from 1 January 2002 to 31 December 2011. Five cases were excluded from analysis due to the presence of a different pathology: four cases of low-grade chondrosarcoma and one case of muco-epidermoid carcinoma.

Thirty-six patients (31.3%) included in the present analysis were treated previously for laryngeal carcinoma by chemo-radiation therapy (12/36, 33.3%), CO<sub>2</sub> trans-oral laser surgery (16/36, 44.4%), open partial laryngectomy (4/36, 11.1%) or cordectomy (4/36, 11.1%).



The tumors were glottic in 103 patients and supraglottic in 12 patients. The vocal fold mobility was: 22 cases with normal or impaired vocal cord mobility (8 supraglottic pT4a and 14 glottic pT2), 44 cases with fixed vocal cord and mobile cricoarytenoid joint (1 supraglottic pT3, 3 supraglottic pT4a, 5 transglottic pT3, 16 glottic pT3, and 19 glottic pT4a) and 49 cases with fixed vocal cord and cricoarytenoid joint (29 glottic-subglottic pT3, 19 glottic pT4a and 1 transglottic pT3).

Resections were classified as follows: STPL-THEP=10 (8.7%), STPL-THEP+A=95 (82.6%), STPL-THP=4 (3.5%), STPL-THP+A=6 (5.2%), where "+A" represents the removal of one cricoarytenoid unit.

The adopted indications for STPL interventions were: A) glottic T2 tumors with anterior subglottic extension, spreading downward above the conus elasticus and reaching the cricoid ring; B) glottic-subglottic T3 tumors spreading within the paraglottic space and controlled by the conus elasticus medially and the perichondrium of the thyroid cartilage laterally (tumor growth is directed downward and laterally, sometimes infiltrating the inferior edge of thyroid cartilage or escaping the larynx between the thyroid and cricoid cartilages through the cricoarytenoid membrane: the so-called early glottic pT4a). Typical clinical features are fixed vocal cord, fixed arytenoid and subglottic swelling; C) transglottic T3 tumors spreading superiorly into the deep tissue of the ventricular band under the quadrangular membrane and progressing into the subglottic area, where they invade the internal lamina or the inferior edge of the thyroid cartilage or the superior edge of the cricoid; D) T3 glottic tumors with paraglottic space invasion and surface extension toward the posterior commissure (a typical radiological feature is the initial sclerosis of the cricoid hemiplate); E) supraglottic T3 of the infrahyoid epiglottis spreading laterally to the petiolus and into the preepiglottic space encompassing the anterior commissure toward the cricoid ring (often escaping the larynx through the thyroid cartilage or cricoarytenoid membrane

with fixation or impaired mobility of the anterior vocal cords but without affecting the arytenoid mobility: early supraglottic pT4a).

The contraindications related to loco-regional extension were: A) glottic-subglottic T3 tumors with massive invasion of the paraglottic space reaching the posterior cricoarytenoid muscle and the pyriform sinus submucosa; B) gross glottic-subglottic T4a with massive cricoid invasion or reaching the first tracheal ring; C) lymph nodes staged N3.

In all patients, resection margins were examined intraoperatively with frozen sections: when positive, the resection was expanded until the margins were negative. The margins of the surgical specimen were always checked again upon definitive pathology. Neck dissection (ND), graded according to the AAO-HNS classification,<sup>19</sup> was performed in 75 patients (65.2%), and was monolateral in 42 (56%) and bilateral in 33 (44%) cases. ND was elective (ND levels II-IV) in 70 cN0 patients (60.8%), and curative (ND levels II-V + Internal Jugular Vein in one case) in 5 cN>0 patients (11.1%). In 55 patients, whole level VI or unilateral paratracheal lymph node clearance was added. No ND was performed in an additional 40 patients (34.8%) with early disease, cN0 disease or in previously treated neck.

#### *Postoperative care and adjuvant treatments*

All patients were monitored for early complications (local and general) and late sequelae. Patients underwent the same rehabilitation protocol, apart from those with serious early complications.

The postoperative protocol consisted of: i) days 1–4: insertion of an uncuffed tracheal cannula and beginning of phonation; ii) days 4–6: during daytime, intermittent occlusion of the tracheostomy with saline-soaked gauze and starting of feeding without the tracheal cannula in position; iii) day 6 onwards, the nasogastric tube (NGT) was removed as soon as a good level of swallowing of both solids and liquids was achieved. Grading of post-

operative aspiration was performed in accordance with Pearson's scale.<sup>4</sup> On the basis of pathological findings (pN+ and/or ECS, large extralaryngeal extension), 31 patients (26.9%) were subjected to adjuvant radiotherapy. The indications for adjuvant therapy were: 7 N+ (5 level VI N+ and 2 N2b) and 24 cases with gross extralaryngeal extension (8 supraglottic pT4a and 16 glottic pT4a).

A large volume encompassing the primary site and all draining lymph nodes was irradiated with a dose of up to 54 Gy/2 Gy. Regions at higher risk for malignant dissemination received a 12-Gy boost (total 66 Gy/2 Gy – range 62–68 Gy). Six of 31 patients also received 100 mg/m<sup>2</sup> cisplatin on days 1, 22, and 43 of the course of radiotherapy.<sup>20, 21</sup>

#### *Larynx functional assessment*

During the five post-operative years, Pearson's Scale evaluation was repeated and larynx functional status was evaluated by the Performance Status Scale.<sup>22</sup>

#### *Statistical methods*

Overall survival (OS), disease-free survival (DFS), loco-regional control (LRC) and laryngeal function preservation (LFP) were estimated at 3 and 5 years using Kaplan–Meier curves. The end points considered were obtained as the length of time from the date of diagnosis to: OS) the date of death; DFS) the date of the first recurrence; LRC) the date of the first loco-regional recurrence; LFP) the date of total laryngectomy or presence of tracheostomy, NGT, gastrostomy feeding, or non-intelligible voice. At the end of the study, the dates of last consultation for patients still alive or free from recurrences or without any laryngeal impairment were used for type-I censoring in the corresponding end point.

pT classification, clinical history of previous treatment and age were evaluated for their correlation with prevalence of OS, DFS, LRC and LFP by log-rank test. The corresponding incidences were evaluated by  $\chi^2$ -tests. All analyses were carried out with GraphPad Prism

version 5.00 (GraphPad Software, San Diego, CA, USA), with  $P < 0.05$  as the significant cut-off.

## RESULTS

### *Patients*

One hundred and twenty patients undergoing STPLs were initially included in this study. After excluding those treated for non-SCC, a cohort of 115 patients was considered (Table 1). Patients were followed for a mean period of 3.37 years. Current or former smokers made up 91% of the cohort.

### *Pathology*

All patients had a biopsy-proven LSCC staged between II and IVa according to the 2002 TNM classification system<sup>23</sup> (Table 1). Furthermore, pathology reports indicated close margins (<2 mm) in 11 cases (9.6%) and in any case were found positive margins at the definitive histopathologic examination. One hundred and ten patients (95.6%) had been classified as cN0 by palpation and neck CT-scan or MRI. Overall, lymph node metastases were detected in 7/115 patients (6.1%), of whom 3 (2.6%) had multiple metastases.

### *Disease control and survival*

The 3-year OS, DFS and LRC were 84.6%, 72.3% and 73.3%, respectively. At 5 years, they were 78.9%, 68.5% and 69.6%, respectively (Figure 1).

### *Correlation of pT category, previous treatment and age to overall survival, disease-free survival and loco-regional control*

Locally intermediate/advanced laryngeal carcinomas are a heterogeneous group of lesions in terms of superficial and depth extent. As a consequence, they differ greatly in surgical indications and prognosis. Therefore, the analyses were conducted on the basis of pathological staging in order to obtain homogeneous prognostic data. By stratifying the chart data, we evaluated whether they could affect the OS, DFS, and LRC in terms of

prevalence (Figure 2). We found that none of the factors affected patients' OS at 5 years. Indeed, the 5-year OS of pT2 tumors was 75.0%, while those of pT3 and pT4a SCC were 82.2% and 73.7%, respectively. The 5-year OS of previously treated patients was very similar to that of untreated patients (80.8% and 79.0%, respectively). There was a small but not statistically significant difference in OS between older and younger patients (70.8% and 82.0%, respectively).

DFS and LRC prevalence at 5 years were greatly affected by local staging. Despite the fact that pT2 and pT3 carcinomas displayed comparable DFS prevalences of 85.7% and 82.9%, the 5-year DFS of pT4a tumors was only 49.0% ( $P < 0.01$ ). Likewise, the prevalence of 5-year LRC was comparable between pT2 and pT3 tumors (85.7% and 82.9%, respectively), but significantly lower for pT4a SCC (51.4%,  $P < 0.05$ ). On the other hand, the clinical history of previous treatment did not affect the 5-year prevalence of DFS and LRC. In fact, the prevalences of DFS and LRC were both 65.1% in pre-treated patients, whereas they were 70.1% and 71.7%, respectively, in patients undergoing STPL as primary surgery. Similarly, age also did not correlate with DFS and LRC: older patients had a prevalence of 62.4% for DFS and 65.6% for LRC, while younger ones had a prevalence of 71.8% for both.

Finally, in terms of incidence, the overall analyses of the end points considered are reported in Table 2.

### *Patterns of failure*

Loco-regional recurrences affected 28 patients within 5 years from surgery. According to the site of pathology, they were sub-grouped as 20 local (71.4%) and 8 regional (28.6%) recurrences.

Local recurrences were observed in 14 (17.7%) untreated and 6 (16.7%) pre-treated patients. Among them, two had subglottic extension and inclusion of a cricoarytenoid joint,

one had surface extension as far as the inferior edge of the cricoid ring, 14 had extralaryngeal extension (9 anterior, 5 posterior) and three showed surface extension toward the posterior commissure.

Inside the larynx, the typical subsites of local failure were the mucosa at the passage between the remnant larynx and trachea or the mucosa at the level of the posterior commissure, as well as outside the larynx at the level of the outer surface of the remnant larynx (probably one of these options: in transit metastasis, lymph node metastases at the level of Berry's ligament, direct invasion of the thyroid gland). The most frequent site of close margins was the posterior commissure mucosa.

In all patients with local recurrence, salvage therapy included total laryngectomy and adjuvant radiation therapy and/or chemotherapy in 16 patients, and laser surgery in four cases. One patient was lost at follow-up, five patients died of laryngeal cancer from progression of disease (average 14.0 months, range 7.4–34.1 months), three patients died of other disease, while at the last follow-up, three patients were alive with the disease and eight patients were alive and disease-free; overall local control after salvage therapy was achieved in eight of 20 patients (40.0%) and at 3 years, the local control rate was 70.0%.

Recurrence in the neck was observed in eight cases, six of whom were previously classified as cN0 and two as cN>0 patients. At the time of primary resection, five of these eight received bilateral neck dissection, and five out of eight recurrences were observed at the VI level. Five recurrences in the neck were treated with surgery and adjuvant radiation therapy and/or chemotherapy, three recurrences with chemotherapy, one of whom also received radiation therapy; three patients died due to regional recurrences (range 3.8–21.0 months, mean 13.7 months), one patient died of other disease while at the last follow-up, one patient was alive with disease and three patients were alive and disease-free.

#### *Postoperative course and morbidity*

Overall acute complications during hospitalization occurred in seven out of 115 patients (6.1%) and there were no perioperative deaths. The mean hospitalization time for patients with acute complications was 38 +/- 6 days, which was significantly longer than that for patients without acute complications (24 +/- 5 days;  $P < 0.01$ ). Late sequelae following discharge were observed in 28 out of 115 cases (24.4%) (Table 3). All were successfully treated with trans-oral CO<sub>2</sub> laser surgery (23/28, 82.1%), injective laryngoplasty using Vox-implants which successfully treated dysphagia (2/28, 7.1%), or total laryngectomy (1/28, 3.6%).

#### *Laryngeal function preservation*

At 5 years, LFP was maintained in 90 out of 115 (78.3%) patients. In addition, we evaluated whether LFP could be affected by local staging, presence of previous treatment or age  $\geq 65$  years (Figure 3). Patients affected by advanced pT or characterized by older age were statistically significantly more prone to lose laryngeal function ( $P < 0.01$ ) with respect to intermediate pT or younger patients. In fact, functionality was maintained in all pT2 and in 91.2% of pT3 patients, but only in 59.3% of pT4a patients. Moreover, LFP was maintained in 84.2% of patients  $< 65$  years old and in only 64.6% of patients  $\geq 65$  years. On the other hand, no statistically significant differences were observed when stratifying patients for previous treatment: laryngeal function was preserved in 79.0% and 75.8% of untreated and treated patients, respectively.

After the first post-operative month, normal swallowing (Pearson's scale Grade 0) was achieved in 66 patients (57.4%), Grade I and II were observed in 25 (21.7%) and 20 (17.4%) patients, respectively, while aspiration pneumonia (AP) (Pearson's Grade III) was recorded in four patients (3.5%). After the second year, a satisfactory degree of laryngeal function (i.e. List's scale: eating in public  $> 50$ , understandability of speech  $> 50$ , Normalcy of diet  $> 70$ ) was achieved in 92 out of 115 patients without local disease (80.0%). Out of



the 92 patients evaluated for subjective aspiration by the Pearson's scale, 23 (25.0%) had no aspiration (Grade 0), 46 (50.0%) had occasional cough without clinical problems (Grade I), and 20 (21.7%) had constant cough that worsened during meals (Grade II). Three patients (3.7%) had frequent pulmonary complications (Grade III). Nearly all patients (112/115; 97.4%) had had the NGT or gastrostomy removed. The NGT remained in place for an average of 21.5 days (range 12–161 days).

Overall, AP was observed in 11/115 cases (9.6%), four cases during hospitalization and seven cases during follow-up. Due to intense dysphagia and AP episodes, a temporary gastrostomy was required in eight patients (7.0%); for five of them, it was removed within the first post-operative year. Only in three cases was the gastrostomy maintained due to repeated episodes of AP and severe dysphagia for liquids. In two cases, total laryngectomy was proposed for persistent aspiration: one patient accepted while the second refused, preferring to keep the gastrostomy and maintain voice. The third patient was subjected to the endoscopic procedure of injective laryngoplasty using Vox implant, which successfully resolved the dysphagia, allowing gastrostomy removal.

The mean time to intermittent occlusion of the tracheostomy was 26.9 days (range 4–406 days), and the average time to tracheostomy closure was 86.3 days (range 29–489 days). In our protocol, progressive closure of the tracheostomy is preferred, and occurs spontaneously in the majority of patients following occlusion. For patients, especially in the first weeks after discharge, this leads to a sensation of greater safety concerning minor episodes of food inhalation, which are relatively frequent. When the tracheostomy has almost closed, minor plastic surgery can then be performed.

## DISCUSSION

The current trend for management of laryngeal cancer indicates that pursuing therapeutic options able to preserve laryngeal functionality provides the best quality of life for patients.<sup>2, 7, 11, 16</sup> To realize this goal, different approaches have been pursued, in terms of chemo-radiotherapy<sup>7</sup> or surgical treatment.<sup>3, 9, 10</sup> The former is able to spare laryngeal function and patient outcome appears satisfactory, nevertheless, loco-regional control is compromised during long-term follow-up.<sup>7, 24</sup> On the other hand, demolitive surgery provides better control of disease, though incurring a higher percentage of laryngeal function impairment and late sequelae that hamper the patients' quality of life.<sup>5</sup> With the diffusion of supracricoid partial laryngectomies (SCPL), the advent of supratracheal partial laryngectomies (STPL), and the consolidated role of conventional non-surgical organ sparing protocols and endoscopic procedures, the role of total laryngectomy in the treatment of endolaryngeal neoplasms has decreased considerably.

In this study, we have analyzed the outcomes of 115 patients affected by LSCC undergoing STPL, a novel laryngeal sparing surgery previously described by our group in 2006.<sup>13</sup>

Glottic tumors with sub-glottic extension (cT3 with vocal cord and arytenoid fixation) may be a problematic category to manage with supracricoid laryngectomy or chemo-radiation, inasmuch as they often result in early pT4a for extra-laryngeal extension. Indeed, the selected cohort of patients considered in our study was composed of a higher percentage of pT4a cases, despite the fact that the amount of supraglottic cancers was lower than in previously described trials.

The 5-year OS in the present study was 79%, better than the ca. 60% observed for both concomitant chemoradiotherapy or induction chemotherapy and radiotherapy.<sup>5, 7, 25</sup> These data were also confirmed for more advanced pT4a tumors that displayed a 5-year OS of 74%. The DFS observed in our study overlapped with that already demonstrated by Wolf

et al. using the demolitive surgical approach (about 70%). These data show that carefully selected patients can achieve good results even with an "extreme partial" surgical approach. However, the DFS for pT4a cancer (49%) was significantly lower than those for the other classifications considered (83% pT3, 86% pT2), but higher than those obtained by management with radiotherapy and/or chemotherapy (ranging from 26% to 38%, respectively).<sup>7, 24</sup> As a consequence, the possibility to develop recurrences was reduced. In fact, the 2-year LRC was maintained in 79% of patients but decreased to 69% at 5 years. Analyzing these data, we can observe that such a trend was due to pT4a tumors, whose 5-year LRC was only 51%. Nevertheless, it is comparable with the LRC detected by Forastiere and colleagues in concomitant Cisplatin/radiotherapy (Cisplatin/RT) management.<sup>7, 24</sup> From this point of view, the total incidence of recurrences after STPL overlapped with that of total laryngectomy demonstrated by Wolf's trial.<sup>5</sup> In the present series, the proportion of patients subjected to total laryngectomy for either functional or oncological purposes, was significantly low (14.8%) and there was no perioperative mortality.

Not surprisingly, the total amount of neck metastases (less than 10%) was lower than in previously reported statistics for demolitive surgery (17%) and demolitive surgery with concomitant chemoradiotherapy (12–22%). These interventions are normally considered in cN0 and cN1 patients, which represent the majority of glottic tumors, even in intermediate/advanced T classification. Finally, the 5-year LFP obtained by STPL was in line with that achievable with concomitant Cisplatin/RT. Maintenance of laryngeal function was critical in patients affected by pT4a cancer (59% at 5 years) and in those older than 65 years (64% at 5 years). Although the function of the remaining larynx is problematic in some cases, both objective and subjective outcomes have demonstrated the quite satisfactory validity of STPLs in sparing laryngeal function, albeit at the obvious expense of a simplified laryngeal framework. This shows the impressive ability of this organ to recover

the essentials of its function after partial surgical mutilation, provided that tissue has been sacrificed and the organ reconstructed according to functional criteria. Based on our experiences, STPLs can be tailored to each patient, depending on the extent of the lesion. This is possible since the larynx tolerates tumor-free margins of only 4–5 mm. Therefore, the radicality of surgery should always be routinely checked intra-operatively by frozen sections.

Nevertheless, persistent slight dysphagia and aspiration pneumonia still represent major complications in patients undergoing STPLs, while voice was significantly deteriorated, and generally quite hoarse and breathy.<sup>26</sup>

In elderly patients (13 patients aged >70 years), cricoarytenoid joint resection had a clear impact, with worsening swallowing recovery: five out of 11 cases of AP occurred in elderly patients, in whom gastrostomy was maintained in one patient owing to repeated episodes of AP, and one was subjected to total laryngectomy. Anyway, high-grade dysphagia and aspiration pneumonia occurred rarely in patients undergoing STPLs if compared with others type of surgical technique, affecting physical and emotional condition of these patients.

In conclusion, our results demonstrate that, in the case of glottic tumors with sub-glottic extension, the choice of STPL versus chemo-radiation protocols can be considered to be viable not only in prognostic terms, but also in terms of functional results such as a reduction in the number of total laryngectomies. This option must be aimed at carefully selected patients with a strong desire to avoid total laryngectomy and suffering from LSCC in well-defined intermediate/advanced stages, often early pT4a for extralaryngeal extension. The gold standard indication is glottic cT3 with vocal cord and arytenoid fixation and sub-glottic extension: the option of a supracricoid partial laryngectomy is very much at risk of leaving positive margins as the section line passes through a cricoarytenoid joint. Nevertheless, even in these cases, it is possible to obtain good oncological and functional

results, even with an “extreme partial” surgical approach. The selection of patients must be made very carefully because, at the end of the work-up, the surgeon should be able to ensure safe margins with sufficient certainty thus avoiding an upfront total laryngectomy. When the tumor clearly extends beyond the limits of the larynx, both the severity of the intervention and the necessity for adjuvant radiotherapy demand that extreme caution be taken when considering the indications.

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## Figure legends

Fig. 1. End point analysis (overall survival, disease-free survival and loco-regional control) of the patient cohort using Kaplan–Meier curves.

Fig. 2. Patient cohort stratification for lesion classification (left column), previous treatment (middle column) and age (right column) using Kaplan–Meier curves. The end points considered were overall survival (top row), disease-free survival (middle row) and loco-regional control (bottom row). Statistically significant differences were seen for patients affected by pT4a tumors in terms of both disease-free survival and loco-regional control. \* =  $p < 0.05$ ; \*\* =  $p < 0.01$

Fig. 3. Evaluation of laryngeal function preservation in the patient cohort stratified for lesion classification (left column), previous treatment (middle column) and age (right column) using Kaplan–Meier curves. Statistically significant impairments were seen in patients affected by pT4a tumors or in those older than 65. \*\* =  $p < 0.01$ .