Abstract: Background. Radiation therapy (RT) is one of the gold standard treatments for early laryngeal cancer, and total laryngectomy is still the most applied surgical procedure after failure. Selected recurrences can be managed by supracricoid partial laryngectomies (SCPLs).

Methods. A multi-institutional retrospective analysis was carried out in 78 consecutive patients treated by SCPLs for the recurrence of glottic-supraglottic cancer after RT. Cricohyoidoepiglottopexy was performed in 62, and cricohyoidopexy (CHP) in 16 cases.

Results. Disease-free survival at 3 and 5 years were 95.5%. Early and late postoperative complications occurred in 27% and 17.9% of cases. Decannulation and satisfactory swallowing were achieved in 97.4% of cases.

Conclusions. SCPLs represent effective surgical organ-preservation strategies in the treatment of selected recurrences after RT failure, resulting in a good local control as well as functional recovery with acceptable morbidity, despite a complication rate which is not negligible. ©2007 Wiley Periodicals, Inc. Head Neck 30: 372–379, 2008

Keywords: laryngeal cancer; partial laryngectomy; supracricoid laryngectomy; radiation failure; organ preservation surgery

In recent decades, refinement in treatment of laryngeal cancer has increasingly focused on tumor eradication and the progressive decrease of postoperative morbidity and permanent impairment of laryngeal functions. To avoid total laryngectomy as much as possible, organ-preservation chemoradiation protocols and conservative surgery have been used for primary treatment of laryngeal cancer, reserving total laryngectomy as salvage treatment.1–3

Local recurrence rate after radiation therapy (RT) ranges from 5% to 13% for T1 and from 25% to 30% for T2 laryngeal cancer.4,5 Surgical management of recurrences after RT failure encompasses endoscopic laser excision,6–8 partial laryngectomies through an open-neck approach,9–13 and total laryngectomy, which still remains the most widely used procedure in such a scenario.14–17
Early and late complication incidences after surgery in irradiated patients are higher and their prevalence increases in relation to the complexity of the surgical technique adopted. Among conservative laryngectomies adopting an external approach, the vertical techniques have been widely performed. However, few reports regarding the use of supraglottic horizontal laryngectomy have been published to date.

Even though many series of supracricoid partial laryngectomies (SCPLs) as a primary treatment can be found in the literature, only a few studies have focused on the possibility of such a surgical technique as a salvage treatment after RT failures. SCPLs (including both SCPL with cricothyroidoepiglottopexy, or CHEP, and SCPL with cricothyroidopexy, or CHP) can be adopted in many mid-sized laryngeal cancers, strictly respecting tumor- and patient-related indications.

The aim of this study was to retrospectively evaluate the oncologic and functional outcomes as well as the complication rate in a multi-institutional Italian cohort of 78 consecutive patients who underwent SCPLs with CHP or CHEP as salvage treatment after RT failure.

MATERIALS AND METHODS
A retrospective analysis was carried out to detect the clinical records of all patients treated between 1987 and 2004 by SCPLs after RT failure for glottic and/or glottic-supraglottic squamous cell laryngeal cancer at 5 different tertiary hospitals, sharing similar therapeutic protocols of recruitment and treatment of patients with laryngeal cancer.

Patients were enrolled according to the following tumor-related criteria: (1) T1 or T2 supraglottic lesions involving the ventricle, the inferohyoid epiglottis, and the false vocal cord, with or without extension to the glottis; (2) T1B or T2 glottic lesions involving the ventricle, false vocal cord, petiole of the epiglottis, and mucosa of the arytenoid; (3) selected T3 transglottic carcinoma with impairment of vocal cord mobility for paraglottic space and/or limited preepiglottic space invasion, without involvement of the arytenoid; (4) selected cases of supraglottic and transglottic T3 carcinoma with minimal invasion of the thyroid cartilage; (5) strictly selected T4A cancer for thyroid cartilage transgression managed with SCPLs removing the adjacent strap muscles “en bloc.”

Good pulmonary and cardiologic functional tests were mandatory.

Absolute contraindications to SCPLs consisted of involvement of the arytenoid cartilage, the cricoarytenoid joint, or the interarytenoid region, hypoglottic extension (1 cm below the vocal cord at the level of the anterior commissure and 0.5 cm posteriorly), massive preepiglottic space invasion, and hyoid bone infiltration. Age was usually not considered as an absolute contraindication when associated to good pulmonary and cardiologic functional tests.

Data from 86 patients submitted to SCPL for recurrence of laryngeal cancer were initially evaluated; 8 patients were subsequently excluded from the analysis (5 lost to follow-up and 3 with incomplete clinical data). Therefore, this study focused on only 78 patients. All of them were men ranging from 33 to 76 years (mean, 59.6 years). Clinical staging was assessed before and after primary RT by means of CT of the larynx and chest, neck and liver ultrasonography (US), and direct laryngoscopy under general anesthesia associated to panendoscopy of the upper aerodigestive tract and biopsy. Pulmonary and cardiac function tests were also performed.

Before RT, patients were clinically staged according to the 2002 TNM staging system as follows: 42 T1a (54%), 18 T1b (23%), and 18 T2 (23%). All of them were N0 (Figure 1).

All patients received RT by Cobalt-60. In the cases of glottic T1a and b (77% of cases), the field of treatment was limited to the larynx with a mean total dose of 64 Gy (2 Gy per day for 5 days per week). In T2 glottic-supraglottic (23% of patients) the field of treatment included neck levels from II to IV with a mean total dose of 66 Gy (2 Gy per day for 5 days per week).

FIGURE 1. T classification at the first diagnosis (cT), at the time of the recurrence (rcT) and after salvage surgery (rpT) in this study’s patient population (N = 78).
Follow-up evaluation included flexible laryngoscopy to assess the response on the primary site and US of the neck every 2 months during the first year after RT and then every 4 to 6 months for the following 4 years. A chest CT was annually performed.

The disease-free interval between RT and salvage surgery ranged from 6 to 193 months (median, 16 months). In all cases, an initial complete macroscopic remission had been reached after RT, so that all failures can be considered recurrences. At the time of recurrence on the primary all patients were clinically restaged. Six of them were classified as rT1a, 30 as rT1b, 33 as rT2, 8 as rT3, and 1 as rT4a (Figure 1). Six patients (7.7%) had simultaneous regional lymph node involvement, classified as follows: N1 in 2 cases (2.5%), N2b in 3 (3.9%), and N2c in 1 (1.2%) (Table 1).

Sixty-two patients (79.5%) underwent CHEP and 16 (20.5%) CHP. One arytenoid was removed in 41 (52.5%) patients: in 33 of those treated by CHEP and in 8 of those treated by CHP. The surgical procedure consisted in the open-neck resection of the entire thyroid cartilage with both true and false vocal cords, including the infrapharyoid portion of the epiglottis in CHEP or the entire epiglottis in CHP. At least 1 arytenoid was always preserved. The residual laryngeal stumps (hyoid bone and cricoid cartilage) were impacted by a pexy with three to five 1-0 nonresorbable sutures. Tracheotomy was always performed between the fourth and sixth tracheal ring before accomplishing laryngeal resection. Intraoperative frozen sections of the resection margins were always obtained. A nasogastric feeding tube was inserted in all patients. Twenty-one (26.9%) patients had simultaneous neck dissection: 15 unilateral and 6 bilateral.

When patients were able to breathe through the natural airway, the tracheostomy tube was plugged (usually 10–12 days after surgery) and definitively removed after 48 hours of effortless breathing in such a condition. Before undergoing surgical closure of the stoma, all patients had a fiberoptic inspection of the neolarynx confirming the adequacy of the airway and the favorable healing of the pexy. Swallowing rehabilitation usually started 12–15 days after surgery, beginning with soft foods. When severe impairment of swallowing was still present, at least 1 month after surgery, a percutaneous endoscopic gastrostomy (PEG) was performed. Voice rehabilitation was started as soon as possible (2–3 days after surgery) to avoid the ankylosis of the crico-arytenoid joint.

Early (within 30 days after surgery) and late complications rates were evaluated (Table 2). Perioperative mortality was considered as any fatal event directly related to a surgical complication or occurring during the first postoperative month.

All patients were clinically followed for a period ranging from 10 to 300 months (median, 70 months) or until death. Disease-free and overall survival rates at 3 and 5 years were estimated by the Kaplan–Meier method.

Table 1. Pre-RT, clinical (before surgery), and pathological T and N categories in patient population in study (N = 78).

<table>
<thead>
<tr>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-RT</td>
<td>Post-RT</td>
<td>Post-surg</td>
<td>Pre-RT</td>
</tr>
<tr>
<td>N0</td>
<td>60</td>
<td>35</td>
<td>26</td>
</tr>
<tr>
<td>N1</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2. Postoperative (early, late, and medical) complications in patient population in study (N = 78).

<table>
<thead>
<tr>
<th>Postoperative complications</th>
<th>Patients, %</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early complications</td>
<td>27</td>
<td>21/78</td>
</tr>
<tr>
<td>Neck abscess</td>
<td>6.4</td>
<td>5/78</td>
</tr>
<tr>
<td>Arytenoid edema</td>
<td>6.4</td>
<td>5/78</td>
</tr>
<tr>
<td>Subcutaneous emphysema</td>
<td>2.5</td>
<td>2/78</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>8.9</td>
<td>7/78</td>
</tr>
<tr>
<td>Pexis dehiscence</td>
<td>1.3</td>
<td>1/78</td>
</tr>
<tr>
<td>Thromboflebitis IJV</td>
<td>1.3</td>
<td>1/78</td>
</tr>
<tr>
<td>Late complications</td>
<td>17.9</td>
<td>14/78</td>
</tr>
<tr>
<td>Hypoglossal granulation tissue</td>
<td>2.5</td>
<td>2/78</td>
</tr>
<tr>
<td>Endolaryngeal infection</td>
<td>1.3</td>
<td>1/78</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>5.1</td>
<td>4/78</td>
</tr>
<tr>
<td>Arytenoid edema</td>
<td>7.7</td>
<td>7/78</td>
</tr>
<tr>
<td>Medical complications</td>
<td>2.5</td>
<td>2/78</td>
</tr>
<tr>
<td>Heart failure</td>
<td>1.3</td>
<td>1/78</td>
</tr>
<tr>
<td>Gastric bleeding</td>
<td>1.3</td>
<td>1/78</td>
</tr>
</tbody>
</table>

Abbreviation: IJV, internal jugular vein.
nearly normal function with daily symptoms and occasional cough during meals; 2, moderately impaired function with constant cough during meals, modified diet, and prolonged meals; 3, impaired function, with limited weight loss and respiratory risk; 4, severely impaired function with loss of more than 10% of the initial body weight in 6 months and pulmonary complications; 5, no safe swallowing. Recovery of a normal breathing was measured as the percentage of decannulated patients and the number of days needed to achieve decannulation. Voice quality was assessed on a perceptual basis by means of the evaluation of a running speech sample by a panel of otolaryngologists and speech pathologists at least 3 months after surgery and graded on a 5-point scale (score 0, normal voice; score 1, minor hoarseness; score 2, grossly hoarse; score 3, nearly aphonc with speech disability; score 4, no intelligible speech). Moreover, we used the maximum phonation time (MPT), defined as the best attempt, among 3, to maximally sustain the vowel “a” at a comfortable intensity as an indirect sign of a good sphincteric function of the neoglottis.

RESULTS
All patients had recurrent squamous cell carcinoma confirmed on the surgical specimen: 8 were classified as rpT1a, 18 as rpT1b, 18 as rpT2, 23 as rpT3, and 11 as rpT4a. Lymph node metastases were pathologically confirmed in 6 patients (7.6%), and were unilateral in 5 (2 pN1 and 3 pN2b) and bilateral in 1 (pN2c). Extracapsular spread was never observed. Pre-RT, clinical (before salvage surgery), and pathological (after salvage surgery) T and N categories are summarized in Table 1.

Three- and 5-year overall survival rates were 85.2% and 81.8%, respectively (Figure 2). Three- and 5-year disease-free survival were both 95.5% (Figure 1). Four patients died of local recurrence, 1 of them in spite of total laryngectomy. Four patients died from lung metastases and 3 from a second primary tumor (2 in the lung and 1 in the liver).

Major medical complications occurred in 2 (2.5%) of 78 patients. One of them died for heart failure on the 30th day after surgery; the second patient had gastric bleedings that required gastric resection on the 12th postoperative day after surgery. Perioperative mortality rate was 1.3%.

Early postoperative complications (before p.o. day 30) occurred in 21 (27%) of 78 patients.

Among these, 5 (6.4%) neck abscess, 5 (6.4%) arytenoid edema, 2 (2.5%) subcutaneous emphysema, 7 (8.9%) aspiration pneumonia, and 1 (1.3%) dehiscence of the pexy. All the complications were resolved with medical therapy and/or compressive dressings.

In 1 patient acute thrombophlebitis of the internal jugular vein occurred on postoperative day 8 and required surgical ablation of the vein because of recurrent bleeding. Late (beyond p.o. day 30) postoperative complications occurred in 14 (17.9%) of 78 patients: 2 (2.5%) had hypoglottic granulation tissue treated by transoral laser resection; 1 (1.3%) had a tracheo-cutaneous fistula at the level of the temporary stoma which required 3 surgical revisions to be resolved; 1 (1.3%) had an endolaryngeal infection successfully treated with temporary suspension of oral food intake and antibiotic therapy; 4 (5.1%) had a postoperative aspiration pneumonia (grade 4) requiring temporary avoidance of oral feeding and adequate antibiotic therapy; and 6 (7.7%) showed persistent arytenoid edema successfully treated by corticosteroids in 5 patients and unsuccessfully managed by endoscopic laser surgery in 1 case.

A nasogastric feeding tube was left in place from 12 to 90 days (mean time, 15 days).

Forty-eight (61.5%) patients recovered their swallowing function within 30 days with a grade 0 or 1 according to the swallowing evaluation scale. Twenty-six (33.3%) patients had prolonged swallowing impairment (grade 2–4), with aspiration pneumonia in 4 (5.8%). Six (7.6%) patients required postoperative PEG because of grade 5 aspiration. PEG was performed in a period ranging from 30 to 48 days after surgery and removed in 4 (5.1%) patients within 3 months. The remaining 2 patients are alive with PEG. Seventy-six
(97.4%) patients recovered satisfactory swallowing (grade 0 or 1) within 3 months after surgery.

The tracheostomy tube was definitively removed in 76 (97.4%) of 78 patients between 12 and 365 days after the surgical procedure.

Decannulation was achieved within 1 and 3 months from surgery in 30 (35.7%) and 72 (92.3%) patients, respectively. Four patients required 123, 167, 181, and 365 days, respectively, to be decannulated.

The median decannulation time was 40 days. Two (2.5%) patients could not be decannulated: 1 died in the immediate postoperative period and a second obtained an insufficient airway because of persistent arytenoid edema in spite of high intravenous doses of corticosteroids and unsuccessful endoscopic attempts of laser resection.

Voice quality was only evaluated in the 76 decannulated patients and was considered to be hoarse to varying degrees in all of them (19 patients grade 1, 49 grade 2, and 8 grade 3). MPT ranged from 2 to 18 seconds (mean, 7.9 seconds).

Hospitalization time ranged from 13 to 95 days (median, 23 days).

**DISCUSSION**

The management of laryngeal recurrence after RT failure remains a controversial issue in spite of an increasing number of articles that have appeared in recent literature. Concerning the role of organ-preservation strategies, a comprehensive approach to the management of these patients is still lacking. We noticed in the present series that many patients with laryngeal cancer after RT failure have an advanced tumor at the time of the recurrence, with a shift from a lower pre-RT category to higher rCT classes. We also noticed a significant difference in the pre-surgical and postsurgical staging, likely due to the increased difficulty in determining the tumor local extension in previously irradiated patients (Figure 1). Therefore, total laryngectomy remains the most frequently performed salvage procedure after RT failure. It guarantees good oncologic results but causes the loss of laryngeal voice and the presence of a permanent tracheostoma.

In recent decades, partial laryngectomies have been used as salvage procedures for the treatment of selected patients after RT failure, representing an attractive method for the management of recurrent laryngeal cancer. In fact, they preserve speech, preserve oral feeding with safe swallowing, and avoid permanent tracheostoma. Nevertheless, strict oncologic criteria need to be followed for patient selection to obtain a successful locoregional control of the disease.

SCPLs are preferable to other conservative surgical techniques because of the wider margin of resection. In fact, the lower limit of resection corresponds to the superior margin of the cricoid, while the cranial limit is represented by the glossoepiglottic valleculae. One arytenoid can be safely removed and therefore the ipsilateral posterior paraglottic space can be completely cleared so that its involvement is not considered an absolute contraindication. Moreover, these organ-preservation surgical techniques avoid partial resection of the thyroid cartilage, such as in vertical partial and horizontal supraglottic laryngectomies, thus avoiding the risk of perichondritis of the residual cartilage stump. Another considerable advantage of SCPLs, when compared with both endoscopic resections and other open-neck partial laryngectomies, is the wider amount of healthy tissue surrounding the tumor that is removed. This feature is particularly important in the case of RT failure, where the correct staging of the tumor is frequently impaired by radio-induced tissue alteration and downstaging can therefore be frequent as shown in Figure 1. Moreover, neoplastic recurrences after RT or chemo-RT protocols do not follow the same pathways observed in previously untreated lesions. In particular, coarctation of the tumor after RT does not necessarily happen concentrically and residual peripheral satellites of viable neoplastic cells can survive even at a distance from the original foci. Even more insidiously, superficially healed mucosa can, also during microscopic examination by a skilled endoscopist, hide deep nests of persistent disease which progress to the visceral compartments of the larynx and/or its cartilaginous framework. This consideration must be taken into account during surgical planning. In fact, the extension of the disease before RT must be carefully considered.

The oncologic value of SCPLs in a post-RT setting is clearly demonstrated by our results in treating rpT1–rpT4 laryngeal cancer, with an overall survival at 3 and 5 years of 85.2% and 81.8%, respectively, and a disease-free survival at 3 and 5 years of 95.5%. Even though we must consider that the enrollment of patients which failed after RT, potentially adds some biases to the analysis, because the procedure is applicable only to selected cases for each T class. However, the data
the contemporary dissection of the superior laryngectomy. The glottic sphincter is totally removed and modification of the hypopharyngo/laryngeal anatomy could cause weakness of sensitive innervation of supraglottic larynx, could cause weakness of sensitive ability and a reduction of the defence reflex. In our series, some impairment of swallowing was present in all cases at the start of rehabilitation, for varying times. The average times until removal of the nasogastric feeding tubes were 16 days and 15 days, respectively, in Naudo et al and our present series without any statistical difference, achieving satisfactory swallowing without gastrostomy within 1 year in 98.4% and 97.4% of the cases, respectively.

Postoperative management of tracheostomy is still under debate. Some authors prefer the initial removal of the nasogastric feeding tube, starting oral alimentation with a tracheostomy tube inside to protect and clean the airways, so permitting the suction of any residual food that may be present. On the other hand, different authors have proposed the early removal of the tracheostomy tube ensuring a rapid mobilization of the residual larynx avoiding any interference with the cough reflex, which limits the incidence of pulmonary infection.

We generally agree with this latter approach, even though in the case of RT failure we feel that a more cautious approach is favorable, because of the expected delay in tissue healing. So particularly in the first time of experience of each institution, the tracheostomy tube was definitively removed only after the complete healing of the pexis and only at the time of the complete resolution of the mucosal edema, which generally persists for longer periods in radiotreated patients. This likely explains the significant delay of decannulation in our series compared with the data reported by Naudo et al (mean time 40 days vs 9 days). In any case, the final decannulation rate within 1 year of 97.4% of the present series does not significantly differ from the 99.5% reported in the French paper.

Regarding speech, voice quality was evaluated in 76 cases in which decannulation was possible. The maximum time during which the vowel “a” was sustained was significantly shorter in patients of our series than in normal adult laryngeal speakers (7.9 seconds vs 16 seconds). This reduced MPT reflects a lesser resistance to the air passage of the neoglottis, which never reaches a complete closure, resulting in air loss during phonation. This altered phonic dynamic also explains the variable degree of hoarseness inevitably present in all the cases evaluated in our series. Satisfactory voice intelligibility was achieved in most
cases. However, our data cannot be compared with the data published by Naudo et al because of the different kind of evaluation scale adopted.

We encountered a low rate of major medical complications (2.5% (heart failure in 1/78 patients and gastric bleedings in 1/78 patients), lower than described by Naudo 5.8%. The data are probably related to the more strict preoperative selection of the patients regarding general condition.

Early postoperative complications occurred in 21 (27%) of 78 patients, against a rate of 10.5% in the Naudo et al series. To compare the 2 groups, we must first remove those cases of pneumonia due to aspiration (8.9%), considered, in any case, as a late complication in the Naudo et al series. In this way, the rate of early complication falls to 18.1%.

Moreover, in our series, the rate of neck-dissected patients was higher than in the Naudo series (26.9% vs 10.5%). Probably this difference affects the early complication rate, which, in any case, was higher in irradiated patients (18.1% vs 10.5%), as expected.

Late postoperative complications occurred in 14 (17.9%) of 78 patients versus 27 (14.3%) of 188 patients of the Naudo et al series (Table 3). All complications except 1 were successfully managed with medical therapy.

**CONCLUSIONS**

SCPLs are useful therapeutic options both for most mid-sized primary laryngeal cancers and for selected cases of recurrence after RT. The oncologic value of such an organ-preservation surgical technique is demonstrated by the high rate of patient survival without any evidence of disease. Swallowing impairment is present in most cases, initially severe, and usually more prolonged than after other partial laryngectomy techniques. Nevertheless, nasogastric feeding tube removal and decannulation rates are similar to those reported for previously untreated patients. Postoperative voice was invariably hoarse but intelligible in all cases. Early and late complication rates are not negligible and certainly higher than in never irradiated before patients, but they do not significantly affect the final functional outcomes. Finally, SCPLs as a salvage treatment modality after RT failure should be viewed as an effective tool in the modern surgical armamentarium, able to offer high expectations of disease control coupled with laryngeal function preservation.

**REFERENCES**