Part III  
Cancer of the Larynx: Radiation Therapy

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The object of treatment, whether by radiation, surgery or both, is to destroy the cancer and to preserve a functionally useful and relatively normal larynx. It must also be borne in mind, however, that radiation failures, often due to uncontrolled local tumor, can be successfully rescued by surgery;1,2 surgical failures from peripheral marginal recurrences are rarely amenable to further surgery and can not be cured by radiation therapy.

The success of radiation therapy is largely influenced by the mobility of the involved cord, depth of tumor invasion, degree of ulceration, gross appearance of the tumor, extent of mucosal involvement and status of the nodes.

Squamous cell carcinoma of the larynx requires a fairly high dose of radiation to a limited volume of tissue with careful treatment technique. To accomplish this, megavoltage radiation energy at or above 1 MeV is highly desirable. Such energy can be generated by a Cobalt 60 teletherapy unit, 2 MeV Van de Graaff generator or a low megavoltage linear accelerator. Because of the inherent physical advantages of these methods—sparing of skin and bone, better depth dose and sharper beam margins—a full course of radiation therapy is generally well tolerated, without significant skin reaction. By using various techniques, such as wedge filter and rotation, maximum radiation is delivered to the tumor with minimum exposure to the adjacent normal tissues. Most irreparable radiation injuries of the soft tissues are greatly reduced and subsequent radical surgery can frequently be performed without complications.

The optimum dosage of radiation for carcinoma of the larynx is dictated by many factors: tumor type and site of origin, irradiated volume, dose per fraction, frequency of treatments and total treatment time. In general, the smaller the volume, the longer the protraction and the higher the dose that can be delivered and tolerated. For lesions with portals measuring 25 to 30 sq. cm., 6500 to 7000 rads are given (NSD value of 1875 to 1950 rads). For most lesions with portals measuring 50 to 60 sq. cm., 6000 to 6500 rads (1770 to 1875 rads) of megavoltage radiation at the rate of 1000 rads divided into five fractions per week should be sufficient therapy. The study of Morrison and Deel3 and others4 has shown that the incidence of tumor control is directly related to the dose delivered.

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GLOTTIC CARCINOMA

Radiotherapeutic Technique

For early carcinoma of the glottis, which has a low incidence of regional lymph node metastasis, the treatment portals should not be large; portals measuring four x five or five x five cm. will usually provide ample coverage. With such a small portal, it is imperative that meticulous treatment “set-up” is carried out to avoid missing the disease by the beam. Since the anterior portion of the vocal cord and the anterior commissure are only one cm. or less from the skin of the anterior neck, the anterior margin of the treatment portals must show a “fall-
Fig. 1A. Computerized (PC-12) isodose curves in the treatment of early glottic carcinoma, using a Cobalt 60 unit, 80 cm. SAD five x five cm² portal. For dose calculations, a 95 percent isodose curve is selected for 6500 rads (NSD value of 1875 rads) in six and one-half weeks. Through opposed lateral open portals, equal loading. Note “cold spot” or low-dose zone in posterior larynx.

Fig. 1B. Through alternating two anterior oblique 45 degree wedged and opposed lateral open portals, equal loading. Note homogeneity of dose distribution within larynx.

Optimum irradiation requires homogeneous distribution of radiations throughout the entire glottic area, as most lesions tend to spread along the free edge of the cord toward the arytenoid. This can best be accomplished by using opposed lateral “open” and wedged portals, anterior oblique wedged pair or a combination of these approaches. (Fig. 1B.) To avoid excessive arytenoidal edema, the posterior half of the arytenoid must be excluded from the high-dose zone. For extensive glottic carcinoma with supraglottic extension, the treatment portal must be large enough to encompass the entire larynx and the regional lymph nodes in the subdigastic, upper and mid-jugular chain region. This type of portal is primarily used as preoperative treatment for T3 and T4 disease. If there is evidence of infraglottic extension, portals should also include the upper tracheal region and the lower jugular nodes.

Results of Radiation Therapy
Because of the low incidence of lymph node metastases in glottic carcinoma, an evaluation of treatment results can only be made according to the extent of the lesion at the primary site (T-status). Many large series have reported on the efficacy of radiation therapy for this disease. In general, the radiotherapeutic results are closely related to the mobility of the involved cord. For an early lesion in which cord mobility is apparently intact (T1), the five-year NED (no evidence of disease) rates
range from 80 to 90 percent.\textsuperscript{1} (Table 1.) For a T1 lesion strictly limited to the anterior third of the vocal cord, a five-year NED rate of 92 percent has been achieved following radiation therapy.\textsuperscript{1} For a superficial lesion involving both vocal cords and the anterior commissure (T1), for example a horseshoe lesion and/or a lesion with supraglottic or infraglottic extension (T2), with normal mobility of the cords, the cure rates using radiation therapy are still excellent, approximately 80 percent.\textsuperscript{1,2} (Table 2.) On the other hand, when a lesion shows impaired cord mobility (T2), the five-year NED rate deteriorates to around 60 percent. (Table 3.) A lesion with complete cord fixation (T3) has an unsatisfactory five-year NED rate of about 25 percent.\textsuperscript{1} (Table 4.)

Local failures following radiation therapy of glottic carcinoma can be rescued by surgery, such as cryosurgery, partial or total laryngectomy. The survival rates are as high as 70 percent.\textsuperscript{1,2} Salvagability is directly related to the mobility of the involved cord or the extent of the initial lesion.\textsuperscript{3}

\begin{table}
\centering
\begin{tabular}{|l|c|c|}
\hline
Status: Normal Cord Mobility & No. of Patients & Percent NED \\
\hline
Anterior two-thirds vocal cord & 191/208 & 92 \\
Both Anterior two-thirds and/or anterior commissure & 34/42 & 81 \\
Entire or posterior third vocal cord & 57/75 & 76 \\
Total & 282/325 & 87 \\
\hline
\end{tabular}
\caption{Radiation Therapy for T1 Glottic Carcinoma\textsuperscript{1} Five-Year Recurrence-Free Rates (Determinate Group)*}
\end{table}

\*Determinate group excluded those patients dead of intercurrent disease, who were found free from recurrence six months prior to death or by postmortem, before five-year mark.

\section*{SUPRAGLOTTIC CARCINOMA}

\subsection*{Radiotherapeutic Technique}

The high incidence of overt and occult cervical lymph node metastases necessitates that supraglottic carcinoma be treated with sufficiently large portals, including the primary as well as cervical nodes in the upper jugular and subdigastic region. This is accomplished by using two large opposed lateral portals with compensating wedges. Curative radiation therapy calls for a dose of 6000 to 6500 rads (NSD of 1850 rads) over six and one-half to seven weeks. The portals should be reduced after a dose level of 4500 rads to avoid excessive radiation to the spinal cord and other vital structures.

\subsection*{Results of Radiation Therapy}

The results of radiotherapy for supraglottic carcinoma are less satisfactory than for glottic tumors. Except for a lesion arising from the tip of the epiglottis, this type of laryngeal cancer has the worst outlook. The five-year survival rates following radiation therapy alone
Supraglottic extension 22/29 76
Infraglottic extension 10/12 83
Transglottic extension 4/4 100
Total 38/45 80

Table 2. Radiation Therapy for T2 Glottic Carcinoma
Five-Year Recurrence-Free Rates (Determinate Group)

| Status: Normal Cord Mobility | No. of Patients | Percent NED |
|-----------------------------|-----------------|-------------|
| Supraglottic extension       | 22/29           | 76          |
| Infraglottic extension       | 10/12           | 83          |
| Transglottic extension       | 4/4             | 100         |
| Total                        | 38/45           | 80          |

vary, depending on the extent of the primary tumor and the status of the cervical lymph nodes. For a superficial, exophytic, early lesion (T1 and T2), cure rates by radiation therapy alone are quite high, ranging from 70 to 90 percent.

On the other hand, if the primary lesion is extensive and deeply ulcerative with fixation of the laryngeal structures and/or associated cervical lymph node metastases, (T3 N1, T4 N1) the five-year rates decrease to approximately 20 to 25 percent. These advanced lesions are presently managed by a planned combined approach, 4000 rads in four weeks followed by total laryngectomy and concomitant neck dissection, with considerably improved results.

SUBGLOTTIC CARCINOMA
Since most patients require emergency tracheostomy when initially seen, subglottic carcinoma has usually been considered within the province of the surgeon and treated by laryngectomy and neck dissection. However, the high incidence of stomal recurrence following surgical extirpation is generally regarded as a deterrent to radical surgery.

Radiotherapeutic Technique
A well-planned program of radiotherapy should include irradiation of the immediate glottis, subglottic region, as well as a portion of the upper trachea and its adjacent cervical lymph nodes. A dose of 6500 rads in six and one-half to seven weeks is generally employed. This can be accomplished through two opposed lateral portals with compensating wedges. Again, shrinking field technique should be used to avoid excessive irradiation of the vital normal structures.

Results of Radiotherapy
Treatment results for this rare condition are rather scanty. Accumulated evidence, however, shows that the small, early tumor may respond favorably to irradiation, with five-year NED rates of approximately 30 to 40 percent.

Postoperative radiotherapy is often recommended to prevent stomal recurrence, but studies of results are sparse.

COMPLICATIONS
Since ionizing radiations effect both normal and neoplastic tissues, some acute and chronic reactions are expected following radical radiation therapy. Most acute effects are temporary, but sympto-
Radiation therapy is the treatment of choice for a T1 and T2 tumor with normal cord mobility and/or an exophytic lesion. It not only provides excellent control of the disease, but also preserves a good, useful voice in approximately 90 percent of the irradiated patients. However, a significant number of patients with laryngeal cancer can be cured by primary surgery alone; total laryngectomy for early cancer should be condemned. "Conservation surgery," such as laryngofissure and cordectomy or partial laryngectomy, in experienced hands, can control early glottic lesions in selected patients, but the functional results are inferior to those of radiation therapy. Radical surgery is reserved for radiation failures.

For a T2 lesion with impaired cord mobility and/or moderate ulceration, a trial course of radiotherapy is initially given. If the tumor shows good regression and/or a return of normal cord mobility after a dose of 4000 rads, radiation therapy may be continued to a curative dose level, about 6500 rads. Surgery is
reserved for treating residual disease six to eight weeks after radiation therapy or for recurrence.

A T3 lesion with complete cord fixation and/or deep ulceration with nodes does not respond favorably to radiation therapy, and a planned combination of irradiation and laryngectomy is advised. Disease that extends beyond the larynx, T4, is rarely curable by radiation therapy alone. If the lesion is still operable, a combined approach of radiation and surgery is preferred; if not, palliative radiation therapy is given. Lymph node metastases from laryngeal carcinoma indicate advanced disease and is managed by preoperative irradiation and radical neck dissection.

Under a program of therapeutic individualization, two-thirds to three-quarters of patients with cancer of the larynx can be cured by irradiation with preservation of a good, useful voice. In the remainder, the larynx must be sacrificed to save the patient’s life. The ultimate control of laryngeal cancer lies in eradicating the extensive primary lesion and metastatic nodes, a common problem in the management of squamous cell carcinoma elsewhere in the body.
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