GENERAL THORACIC SURGERY

CONCOMITANT TYPE I THYROPLASTY AND THORACIC OPERATIONS FOR LUNG CANCER: PREVENTING RESPIRATORY COMPLICATIONS ASSOCIATED WITH VAGUS OR RECURRENT LARYNGEAL NERVE INJURY

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Objectives: We sought to prevent postoperative swallowing disorder, aspiration, and sputum retention in cases of recurrent laryngeal or vagus nerve section occurring during lung cancer resection.

Methods: In 14 of 25 consecutive patients, type I thyroplasty and thoracic operations were performed during the same period of anesthesia. All patients had a preoperative laryngeal computed tomographic scan providing us with indispensable measurements for vocal fold medialization under general anesthesia (ie, without intraoperative phonatory control). Nine remaining patients had a type I thyroplasty delayed from thoracic operations because of intraoperative doubt about laryngeal innervation injury, and 2 did not need a laryngeal operation. Main postoperative records consisted of swallowing ability, respiratory complications, and quality of voice.

Results: No swallowing disorder, aspiration, or sputum retention occurred in cases of concomitant laryngeal and thoracic operations. Of these 14 patients, a single case (7%) of major complication (vocal fold overmedialization) occurred and required an early and successful revision thyroplasty; one case of cervical hematoma that did not require surgical drainage was considered a minor complication (7%). Twelve (86%) patients who underwent the concomitant association of both operations were fully satisfied with their quality of voice.

Conclusions: Type I thyroplasty and thoracic operation can be advantageously associated in case of injury to laryngeal motor innervation to prevent postoperative swallowing disability and dramatic respiratory complications. (J Thorac Cardiovasc Surg 2001;121:642-8)

The surgical treatment of lung carcinoma most often consists of tumor resection associated with mediastinal lymph node dissection. Because of their anatomic location, the left vagus nerve (VN) and recurrent laryngeal nerve (RLN) are exposed to cancer invasion and to surgical injury. From our own experience, we have learned that surgical severing of these nerves results in vocal cord abduction in most cases, whereas mild injury

to these nerves is more likely to result in a paralyzed vocal cord in the intermediate position (unpublished data). This impaired laryngeal mobility can be dramatic after lung resection because of postoperative respiratory complications caused by a glottic gap. Swallowing disorder is a major consequence of such a glottic incompetence¹⁻⁴ and can be life-threatening in patients just operated on for lung cancer.^{1,5} Also frequent, in cases of laryngeal paralysis, is an ineffective cough that increases the risk of pulmonary infections.⁶ To quickly restore glottic competence, one can choose between 2 types of procedures: intrafold injection or a medialization operation. Currently, for numerous teams, laryngeal framework operations for vocal fold medialization, such as type I thyroplasty, are considered better techniques than intrafold injection for laryngeal rehabilitation.⁷⁻⁹

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Whatever the type of laryngeal procedure chosen, early glottal rehabilitation has to be rapidly achieved to prevent serious pulmonary complications in such patients. It would be even better to avoid or minimize postoperative glottic insufficiency any time the VN or RLN has been severed during thoracic operations. This report shows that type I thyroplasty can be associated with lung cancer resection during the same period of general anesthesia, with success and a low morbidity rate when the laryngeal innervation has been severed during the thoracic surgical procedure.

Patients and methods

Patients. In a preliminary series of patients operated on for lung cancer (unpublished data), we unsurprisingly observed that in cases of VN or RLN section, about 50% of patients had postoperative respiratory complications caused by glottic insufficiency that were sometimes life-threatening. In these cases a type I thyroplasty was achieved, with success within the first postoperative week. Then, in all cases of intraoperatively recognized VN or RLN section that occurred during thoracic operations for lung cancer from November 1998 to February 2000, we performed a type I thyroplasty during the same period of general anesthesia immediately after thoracic wound closure. This association of concomitant type I thyroplasty and lung cancer resection during the same general period of anesthesia is herein referred to as *CTLC*. Delayed type I thyroplasty performed a few days after the thoracic operation because of intraoperative doubt about VN or RLN injury is herein referred to as *DTLC*.

Preoperative records. Characteristics of each patient were noted (including historical background) at the first visit to the thoracic surgeon. A preoperative visit to the otolaryngologist aimed at verifying the integrity of the upper aerodigestive tract because lung and head and neck cancers are often associated.^{1,10,11} Examination by the otolaryngologist included a fiberoptic visualization of the larynx. All patients were informed they could also be operated on for vocal fold medialization in case of VN or RLN section. A preoperative computed tomographic (CT) scan of the larynx allowed us to obtain the following laryngeal measurements: distance between the left thyroid lamina and the midline; thickness of the left thyroid lamina; and thickness of the left soft tissues of the larynx from the medial border of the vocal fold to the medial border of the left thyroid lamina at the junction of the anterior and middle thirds of the vocal fold (Fig 1). The midline was identified on CT scans acquired during phonation, whereas the thickness of lateral soft tissues of the larynx required an open glottis to be measured. As shown in Fig 1, *d*, the maximal distance that could be covered by vocal fold medialization was measured from the inner side of the thyroid lamina to the midline along the perpendicular line to the thyroid lamina joining it to the junction of the anterior and middle thirds of the vocal fold.

Criteria required for concomitant type I thyroplasty and lung cancer resection. In case of concomitant head and

neck tumor, the patient was first treated for the tumor and then operated on for his or her lung cancer (only 1 patient who did not eventually require a thyroplasty). A preoperative laryngeal CT scan was always required for *CTLC*. To allow a *CTLC* to be achieved, the thoracic team had to be sure the laryngeal innervation had been severed. Therefore, some patients did not undergo a *CTLC*, whereas they did have a postoperative laryngeal paralysis because the VN or RLN injury was intraoperatively uncertain.

Surgical procedure. Once the thoracic wound had been closed, the tracheal tube was changed for a smaller one (internal diameter size, 6.5 or 7 mm) to facilitate the vocal fold medialization. The patient was then laid down on his or her back, with the neck extended and the head slightly rotated to the right. The principle of the surgical technique we used was essentially described by Isshiki and associates^{12,13} in the English literature. In brief, a lateral cervical approach to the left thyroid lamina was achieved, and a chondral graft was harvested from the superior border of this cartilage. The graft was then thinned out as much as required according to CT scan measurements. A cartilage window was made at the level of the vocal fold by using a 1-mm diamond burr. The cartilage window was not removed but impacted toward the midline so as to medialize the vocal fold. The medialized cartilage was then maintained in place with the help of the chondral graft. The latter was vertically placed over the thyroid window and sandwiched between the thyroid lamina and the impacted thyroid window (Fig 2). Great care was taken to preserve the internal layer of perichondrium. An aspirative drain was placed, and the neck wound was closed in layers. The thickness of the graft that was interposed between the thyroid lamina and the impacted cartilage window was based on the preoperative CT scan measurements, as follows:

$$G = \text{MaxD} - (\text{TL} + \text{ST}),$$

where *G* is defined as the thickness of the graft, *MaxD* as the maximal medialization allowed, *TL* as the thickness of the thyroid lamina, and *ST* as the thickness of the lateral soft tissues of the larynx.

Postoperative records

Voice assessment and swallowing ability. Patients were asked to score the quality of their voice after thyroplasty as follows: 1, poor voice; 2, acceptable voice; or 3, completely satisfying voice. Patients who were not able to drink mineral water without aspiration were considered to have a swallowing disorder. These 2 criteria were assessed at postoperative day 1, after 1 postoperative month, and 6 and 12 months after the surgical procedure whenever possible.

Postoperative vocal fold position. The vocal fold position as visualized through nasofibrosopic examination was quoted as excessive (overmedialization), perfect (medial position), acceptable (paramedian), or poor (failure of correction). This fiberoptic laryngeal examination was performed as early as the first postoperative day, unless the patient needed prolonged mechanical ventilation in the intensive care unit. In addition, CT scan measurement of the glottic gap during phonation was achieved after 1 postoperative month, whenever possible, at the middle third of the vocal fold.

Table I. Characteristics of patients

Patient No.	Age (y)	Sex	Type of tumor	UICC staging (1997)	Neoadjuvant treatment	Type of operation	Type of nerve impairment	Time of thyroplasty (re: time of thoracic operation) (d)
1	67	M	Epidermoid	T2 N2	None	Sl	VN section	29
2	55	M	Epidermoid	T1 N0	None	Pn	Neuropraxia	81
3	75	M	Epidermoid	T4 N2	None	Pn + Pl	RLN section	6
4	69	M	Epidermoid	T1 N1	Ch	Pn	RLN and VN section	13
5	71	F	Adenoid cystic carcinoma	T4 N2	None	Pn + Pc	VN section	0
6	68	M	Epidermoid	T3 N2 M1	Ch	Pn + Pc + Pl + Cos	RLN and VN section	0
7	48	M	Epidermoid	T4 N3	Ch	Pn + Pc	Unknown	No thyroplasty
8	57	M	Epidermoid	T2 N1	None	Pn	VN section	0
9	57	F	Epidermoid	T2 N2	Ch	Pn + Pc	RLN and VN section	0
10	71	M	Epidermoid	T4 N0	None	Pn + Pc	RLN and VN section	0
11	62	M	Epidermoid	T4 N1	None	Pn	Unknown	0
12	60	M	Epidermoid	T2 N0	Ch	Pn	VN section	0
13	65	M	Adenocarcinoma	T2 N1	Ch	Pn + Pc	Unknown	5
14	64	M	Epidermoid	T2 N0	None	Pn + Pc	RLN and VN section	0
15	73	M	Epidermoid	T4 N1	Ch + Rx	Pn + Pc + Pl + Cos	RLN section	0
16	70	F	Adenocarcinoma	T1 N0	None	Sl	RLN section	No thyroplasty
17	62	F	Adenocarcinoma	T2 N2	Ch	IL + Pc	RLN and VN section	0
18	48	M	Adenocarcinoma	T1 N0	None	Sl	RLN section	10
19	64	F	Epidermoid	T3 N0	Ch + Rx	Sl + Pl + Cos	RLN and VN section	0
20	49	M	Epidermoid	T4 N1	Ch	Pn + Pc + Atr + Car	RLN and VN section	0
21	57	M	Adenocarcinoma	T3 N2	Ch	Pn + Pc	RLN section	0
22	60	M	Epidermoid	T4 N2	Ch	Pn + Pl	RLN and VN section	27
23	50	M	Epidermoid	T3 N0	Ch	Pn + Pc	RLN and VN section	31
24	57	M	Adenocarcinoma	T2 N2	None	Pn + Car	VN section	6
25	68	M	Epidermoid	T2 N1	Ch	Pn	RLN and VN section	0

UICC, International Union Against Cancer; Sl, superior lobectomy; Pn, pneumonectomy; Pl, pleurectomy; Ch, chemotherapy; Pc, resection of pericardium; Cos, costal resection; Rx, radiotherapy; IL, inferior lobectomy; Atr, partial atrial resection; Car, resection of carina.

Postoperative complications. Postoperative complications were all listed with special attention to those caused by swallowing disability. Respiratory complications considered as consequences of swallowing disorder included pneumonia and postoperative bronchoscopy for major sputum production.

The length of hospitalization was defined as the number of postoperative days actually spent in our institution, including the stay in intensive care unit.

Data analysis. Characteristics and history of patients before the thoracic surgical procedure, hospitalization duration, postoperative swallowing ability and quality of voice, postoperative respiratory complications, global morbidity, and morbidity specifically related to the additional laryngeal operations in the case of patients undergoing CTLC were noted. Quantitative results were expressed as means of raw data $\pm$ SD. Data collection was done before the surgical procedure, as soon as after detubation (ie, usually the day of surgery), and after the first, sixth, and twelfth postoperative months.

Results

From November 1998 to February 2000, 71 patients were operated on for left lung cancer in our institution. Twenty-three (32%) underwent a surgical left vocal

fold medialization; they were 19 men and 4 women (mean age, 62 ± 8 years). Fourteen (10 men and 4 women) underwent a CTLC. Eleven patients did not undergo CTLC but only left lung resection because the VN or RLN section was not intraoperatively certain. Nine of them needed a delayed type I thyroplasty (DTLC), and 2 did not because they remained able to swallow and clear their bronchial secretions despite laryngeal impairment. Mean follow-up for the whole series of type I thyroplasty cases was 9.8 ± 5 months. Table I indicates the cancer characteristics of each patient, the type of nerve impairment, and the time when the laryngeal operation was performed. The mean length of the laryngeal framework operation was 51 ± 9 minutes (range, 40-70 minutes). Table II shows the length of total hospitalization and intensive care unit stay. Three patient died before the end of hospitalization. Death occurred in 2 patients undergoing CTLC (cardiogenic pulmonary edema in both cases) and in 1 patient undergoing DTLC (sudden death without respiratory distress). No death could be directly imputed to thyroplasty.

Morbidity of thyroplasty. Of the patients undergoing CTLC, only one had a major complication of thyroplasty (ie, 7% of patients undergoing CTLC, 5% of all patients undergoing thyroplasty achieved under general anesthesia, and 4% of all patients undergoing thyroplasty), which consisted of an overmedialization of the vocal fold. This case was difficult to diagnose because the patient had severe asthma, and thus dyspnea was likely caused by asthma and overmedialization of the vocal fold. A revision thyroplasty was performed on postoperative day 2 to avoid a tracheal reintubation. The chondral graft was removed, thinned out (1 mm), and placed back over the thyroid window. This patient felt partly relieved from dyspnea after the second laryngeal surgical procedure but still had persistent dyspnea caused by asthma. It is interesting to note that in this case the thyroid was small and less triangular than usual, giving to the larynx a rounded shape that made it difficult to exactly determine the degree of vocal fold medialization. In addition, the midline was not clearly identifiable on the preoperative CT scan because of the lack of phonatory images of the larynx. Apart from this case, a cervical hematoma occurred once, as the result of a failure of aspirative drainage. It did not require surgical drainage but only local care and was considered a minor complication.

Thyroplasty in patients undergoing DTLC was carried out under local anesthesia in only 4 patients because the other such patients were usually exhausted and too dyspneic to undergo a laryngeal operation under local anesthesia for about 1 hour. No complication directly related to thyroplasty occurred in cases of DTLC.

Effects of thyroplasty

Postoperative voice and swallowing ability. Type I thyroplasty gave a 100% success rate on swallowing ability. This was our main goal, especially in patients undergoing CTLC. This good result on deglutition was maintained up to the first postoperative month in all patients and in all patients controlled at the sixth postoperative month ($n = 9$) and after 1 year ($n = 5$). The quality of voice was given a score of 3 in all patients undergoing DTLC. Of the 13 patients undergoing CTLC, 11 gave a score of 3 for their vocal quality and 2 gave a score of 2.

Postoperative vocal fold position. Fiberoptic laryngoscopy performed in the early postoperative period was satisfactory and there was no laryngeal dyspnea in all cases but one. In all patients but one, no glottal gap was observed during phonation. It is noteworthy that in the latter patient, swallowing ability was good, with no aspiration. The glottic gap measured on CT scans after 1 postoperative month was, on average, 0.43 ± 0.4 mm

Table II. Length of intensive care unit stay and length of total hospitalization

Patient No.	Length of ICU stay (d)	Length of hospitalization (d)
1	1	39
2	0	13
3	NA, died at d 12	
4	13	77
5	8	24
6	0	12
7	0	9
8	12	23
9	0	9
10	163	163
11	NA, died at d 14	
12	4	9
13	0	14
14	NA, died at d 13	
15	32	50
16	0	12
17	0	10
18	0	18
19	0	10
20	9	16
21	0	9
22	20	37
23	41	75
24	2	12
25	70	90

ICU, Intensive care unit; NA, not applicable.

in the CTLC group (range, 0-0.94 mm) and 0.26 ± 0.5 mm in the DTLC group (range, 0-0.8 mm), which is a global average of 0.37 ± 0.4 mm for all patients having undergone a thyroplasty. Patient 2, who underwent a delayed type I thyroplasty, is remarkable in that he eventually recovered his vocal fold mobility 1 year later, although he underwent a laryngeal framework operation.

Discussion

The main result of this report is to show that the association of concomitant lung cancer resection and type I thyroplasty is effective in lowering postoperative complications when the VN or RLN are injured. To our knowledge, this association of concomitant lung cancer resection and type I thyroplasty achieved during the same period of general anesthesia had never been reported before. The worst case of complication reported herein was an overmedialization of the vocal fold that was early and easily corrected. We are now more demanding on the quality of preoperative CT scans of the larynx, which must include phonatory pictures. Indeed, because thyroplasty was achieved under general anesthesia in patients undergoing CTLC, it was not

Fig 1. Preoperative CT scan. **a**, The midline is determined on phonatory scans, and the axis of the left thyroid lamina is marked by a solid line. **b**, Measurement of the thickness of the future chondral graft. **c**, Thickness of left laryngeal soft tissues (glottic and paraglottic tissues) is measured on an open glottis. **d**, Measurement of the maximal distance that can be covered by vocal fold medialization is obtained between the inner border of the thyroid lamina (line 3) and the midline (line 1). The thickness of the cartilage window that will be detached from the thyroid lamina is measured between lines 2 and 3.

possible to intraoperatively test the quality of voice, as is usually done.^{12,13} Cervical hematomas were easily prevented by means of high enough vacuum wound drainage. However, we strongly recommend use of effective aspirative drainage because these patients are at risk of laryngeal hematoma.

Thyroplasty duration of about 50 minutes was acceptable in such cases since all patients tolerated this additional operative period. In particular, no increase in

thoracic infection was noted. Inherent complications of thyroplasty were as much lowered as possible. Even though most surgical teams prefer to use silicone implants,^{12,14,15} some complications caused by the use of silicone have been reported, such as prosthesis extrusion or migration^{16,17} or even allergy to the solid silicone implant.¹⁸ We avoided all problems related to foreign body insertion by choosing to medialize the paralyzed vocal fold with chondral autografts not only

in patients undergoing CTLC but also in those undergoing DTLC. Type I thyroplasty has already been reported to be reversible, and we can confirm this point. It was possible, at the second postoperative day, to replace the graft in patient 14 without any problems. Additional evidence of minimal invasion of thyroplasty is given by the case of patient 2 (DTLC). In this patient the paralyzed vocal fold completely recovered its mobility 1 year after thyroplasty, although the course of the left vocal fold was shortened by the chondral graft.

The low morbidity rate of CTLC, imputable to laryngeal framework operations, is satisfactory, inasmuch as postoperative swallowing disorders and sputum retention could be avoided in all cases despite the vocal fold immobility. Undoubtedly, swallowing disorders are to be certainly avoided in case of lung operations for cancer because they can be responsible for fatal respiratory complications.⁵ In cases in which the vocal fold innervation is severed during lung operations for cancer but no laryngeal operation is performed, we know from our own experience that aspiration can be expected in about one third of patients (unpublished data). In the current series, out of the 11 patients who did not undergo a CTLC but who eventually experienced postoperative laryngeal paralysis, only 2 (18%) did not need a type I thyroplasty. Other teams also have reported high rates of aspiration after alteration of laryngeal mobility, some as high as 53%¹⁹ or 73%.²⁰ This point in itself justifies the realization of CTLC. The excellent result regarding swallowing ability lasted at least as long as 1 month in all patients. All patients seen after several months (9 at 6 months and 5 at 1 year) had a persistently good swallowing ability. Postoperative laryngeal examination and CT scans show that even though a glottal gap might persist, swallowing disorders were avoided in all cases. It is possible that glottic closure can be obtained because of the Bernoulli effect, even though the vocal fold position is incompletely corrected, provided that the residual glottic gap is not too large (see Isshiki⁸): the airflow passing through the glottal gap sucks the vocal fold mucosa to the midline because of the midline negative pressure created by the airflow.

The postoperative quality of voice, as subjectively assessed by the patients themselves, was satisfying in our series. None of our patients were voice professionals, however.

Delayed thyroplasty or other laryngeal procedures let patients incur respiratory complications that can be dramatic before laryngeal rehabilitation is achieved. In another type of patients (ie, those undergoing skull base operations), it has recently been recommended to perform a laryngeal rehabilitation early after injury to the

Fig 2. Vocal fold medialization: intraoperative view (left side of the thyroid cartilage). The graft has been interposed between the cartilage window and the remaining thyroid lamina. *Ant*, Anterior; *Inf*, inferior; *TL*, thyroid lamina.

VN, as soon as postoperative day 2, to lower the postoperative complication rate.²¹ It is of even greater interest to be able to prevent such complications whenever possible. Coupling type I thyroplasty and lung cancer resection, whenever injury to the RLN or VN is recognized, meets this goal and results in an acceptable morbidity rate.

Finally, because CTLC can be a safe procedure in the vast majority of patients and prevents postoperative respiratory complications caused by laryngeal dysfunction, we do recommend it in cases of RLN or VN section.

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