Comparison Between Laser- and Diathermy-Assisted Posterior Cordotomy for Bilateral Vocal Cord Abductor Paralysis

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**IMPORTANCE** A reliable procedure is needed to solve the problem of difficult airway in patients with bilateral vocal cord paralysis without adversely affecting patient "voice quality."

**OBJECTIVES** To compare the results of laser-assisted posterior cordotomy with diathermy-assisted posterior cordotomy for bilateral vocal cord paralysis in regard to dyspnea severity, voice quality, and aspiration.

**DESIGN** Prospective randomized clinical trial at a university medical center.

**SETTING** Zagazig University Hospitals, Zagazig, Egypt.

**PARTICIPANTS** Twenty patients randomly categorized into 2 groups; group A was treated with laser-assisted posterior cordotomy and group B was treated with diathermy-assisted posterior cordotomy.

**INTERVENTION** Laser-assisted posterior cordotomy for group A and diathermy-assisted posterior cordotomy for group B.

**MAIN OUTCOME AND MEASURE** Dyspnea severity, voice quality, and aspiration.

**RESULTS** A significant difference ($P < .05$) was found between group A and group B at all postoperative comparisons in dyspnea, whereas no significant difference ($P \geq .05$) was detected at all postoperative comparisons in voice quality.

**CONCLUSIONS AND RELEVANCE** Laser-assisted posterior cordotomy can be considered as a reliable and superior procedure compared with diathermy-assisted posterior cordotomy in the treatment of bilateral vocal cord abductor paralysis.

**TRIAL REGISTRATION** clinicaltrials.gov Identifier: ISRCTN08093874
Bilateral vocal cord paralysis (BVCP) is a potentially life-threatening condition that frequently requires some kind of surgical intervention to prevent acute asphyxia or chronic central airway obstruction. The objectives of treatment of BVCP are to achieve adequate airway and to preserve voice quality and laryngeal competence. Several surgical procedures have been suggested for treating this condition. In 1922, Jackson suggested a ventriculocordectomy technique through external passages. In 1946, Woodman developed infarction of endoscopic static procedures for the treatment of BVCP. In 1994, Rontal and Rontal suggested an arytenoidectomy technique through extralaryngeal access and surgical of the vocal process to the inferior horn of thyroid cartilage to lateralize the vocal cord.

Endolaryngeal accesses were introduced in 1948 by Thornell, who proposed arytenoidectomy with electric cauter. Arytenoidectomy and posterior cordotomy using a carbon dioxide laser was introduced by Ossoff et al and by Dennis and Kashima, respectively. In 1994, Rontal and Rontal reported a new method, a so-called laryngeal muscular tendon, whereby the vocal ligament, thyroid arytenoid muscle, and interarytenoid muscle are sectioned by their insertions on the arytenoid cartilage. This surgical approach aimed to eliminate adductor forces over the arytenoids cartilage with a predominance of abductor action of posterior cricoarytenoid muscle. With the addition of a laser, increased interest developed in favor of endoscopic static procedures for the treatment of BVCP.

The aim of this work was to compare the results of laser-assisted posterior cordotomy (LAPC) with those of diathermy-assisted posterior cordotomy (DAPC) in terms of improvement of airway, quality of voice, and laryngeal sphincter mechanism. The ethical committee of Zagazig University, Zagazig, Egypt, approved this study, and written formal consent was signed by patients or their relatives.

**Methods**

This prospective study was performed in the Department of Otorhinolaryngology–Head and Neck Surgery, Zagazig University Hospitals, from February 2008 to April 2011 in 20 patients (4 men and 16 women), who were diagnosed as having bilateral abductor vocal cord paralysis after thyroidectomy surgery, except for 1 patient whose disease had idiopathic etiology. All patients had had BVCP for at least 1 year. They all had a respiratory chink of a maximal width of 4 mm or less.

The patients were randomly categorized into 2 groups. Group A was treated with LAPC. Group B was treated with DAPC. All patients provided a detailed medical history and underwent routine systemic, head and neck, neurologic, and otorhinolaryngological examinations.

Each patient was examined by a phoniatrician before and after surgery using the voice assessment protocol. This protocol passes through the following levels:

1. **Elementary Diagnostic Procedures**
   This includes auditory perceptual assessment (APA) of the patient’s voice as a subjective evaluation of the voice with careful laryngeal examination. The presence or absence of vocal fold visible mobility was determined, and its side and degree (normal or restricted) and the direction of restriction (abductor or adductor), in order to confirm the diagnosis. Also, the phonatory gap (the gap between vocal folds during normal phonation) and respiratory chink (the maximal glottic gap during respiration) were determined subjectively. They were measured in millimeters at their widest point compared with the length of the visible membranous vocal fold (proposed to be 15 mm in males and 10 mm in females).

2. **Clinical Diagnostic Aids**
   This level includes laryngovideostroboscopy (LVS) using flexible nasofibroscope connected to a camera in association with stroboscopic light. The presence or absence of vibratory behavior, mucosal wave, symmetry, periodicity, and areas of absent vibrations were determined. Then documentation of the APA was done by means of high-fidelity voice recording. The speech material recorded included reading a standardized text, a counting task, and sustained vowel prolongation, including /a/, /i/, and /u/ vowels. The recordings were done in a sound-treated room to minimize environmental noise. The recorded materials for all patients were rated using the modified GRBAS (grade, roughness, breathiness, asthenia, strain) scale, which was confirmed by 3 experienced phoniatricians. This scale comprised a 4-point scale (0 for normal to 3 for severe) for determining the items: overall grade of dysphonia, and character of voice including strained, leaky, breathy, and rough.

3. **Additional Instrumental Measures**
   This level of assessment includes acoustic analysis of voice using the (Vocal Assessment software [version 4.5; Dr Speech]). The patient was asked to pronounce a prolonged /a/ in front of a microphone as long as possible after taking deep inspiration. The following parameters were analyzed automatically: percentage of jitter, percentage of shimmer, and noise to harmonic ratio. Maximal phonation time (MPT) can be measured simultaneously during the same task.

Patients were followed at 1-week intervals for 1 month then at monthly intervals for 1 year. Data collection included grade of dyspnea, aspiration problems grade of dysphonia, acoustic analysis of voice, and MPT. Severity of dyspnea in the preoperative and postoperative periods was categorized as none, mild, moderate, severe, and very severe according to the dyspnea severity scale (Table 1). Postoperatively, aspiration was evaluated according to the Pearson scale (Table 1).

**Surgical Technique**

This procedure was performed under general anesthesia. Patients who had a tracheostomy in situ at the time of presentation were given anesthetic gases through a tracheostomy tube while those without a tracheostomy were intubated orally using a small-sized cuffed endotracheal tube. Surgical cottonoid moistened with saline was kept in the subglottis to protect the endotracheal tube cuff. An appropriate-sized laryngoscope was used and suspended to expose the larynx. The larynx was sprayed with xylocaine, 4%, solution. A surgical microscope (Zeiss) with 400-mm lens was used to visualize the vocal cords. After the larynx was explored, palpation was used to discard...
fixation of the arytenoid cartilage. The junction of vocal process of the arytenoids with the membranous part of the vocal cord was identified by palpation with a microbore metallic laryngeal suction catheter.

The selection of the side of surgery depended on the presence—even minimal—of active mucosal wave by LVS. The side that showed more vibratory behavior was excluded. If there was no difference between both sides the decision was left to the surgeon. Only 1 side was operated on at a time. If bleeding was encountered, it was controlled by applying pressure with a cotton swab soaked in adrenaline (1:1000) to the cauterized area with laryngeal cup forceps for a few minutes. No topical agent, such as mitomycin C, was applied in this study.

**Laser-Assisted Posterior Cordotomy**

Laser-assisted transverse incision at posterior part of membranous vocal cord just anterior to the vocal process of arytenoid (LAPC) was made by carbon dioxide laser (model 1055S; Sharplan), attached to the operating microscope with a micromanipulator. The laser was set to 3 to 5 W, a 0.4-mm spot size, focused beam, and continuous superpulse mode. A 50-cm² syringe filled with cold saline was always available to deal with endotracheal tube fire combustion. The patient’s face was protected by large moist surgical gauze. A microsurgical suction tip for continuous smoke vapor suction was used. Injury to the anterior two-thirds of vocal cord and to any other part of laryngeal mucosa was avoided. Exposure of the cartilage of the vocal process of arytenoid or the inner surface of thyroid cartilage was also avoided. A transverse incision was made through the entire vocalis and thyroarytenoid muscle. In this way, a wedge-shaped area was created owing to recoil of the cut ends of the membranous cord.

**Diathermy-Assisted Posterior Cordotomy**

A diathermy-assisted transverse incision was planned at the posterior part of membranous vocal cord (DAPC) just anterior to the vocal process of the arytenoids. This was accomplished with a straight active cutting electrode of electrocautery with a 0.45-mm diameter and a 23-cm working length (model 8888 C; Storz). A Conmed Sabre 2400 electrocautery machine was used, and the power was set at 20 W, which was the lowest cutting setting on this machine. The passive electrode of the electrocautery machine was applied to the left calf. Care was taken not to expose the cartilage. The active electrode is insulated throughout its length to avoid mucosal injury except at its distal cutting edge. For better control, a foot switch of electrocautery was used by the surgeon to activate the electrocautery. Injury to the anterior two thirds of vocal cord and to any other part of laryngeal mucosa was avoided. A transverse incision with electrocautery was carried out through the entire vocalis and thyroarytenoid muscle but owing to thermal energy produced by the diathermy electrode, the resulting cut was more like a posterior cordectomy rather than a line transverse cordotomy.

**Postoperative Management**

Dexamethasone sodium phosphate, 4 mg, was intravenously given to all patients during the operation to reduce laryngeal edema. This was repeated twice in 24 hours after the operation and was followed by a 5-day course of oral steroids (prednisone, 1 mg per kilogram of body weight), which was then tapered over the next 5 days. In addition, broad spectrum prophylactic oral antibiotics were given for 5 days after the operation. Patients who had undergone a tracheostomy were decannulated after a weaning test.

Postoperative voice assessment was done at each follow-up visit and at the end of the follow-up period. Preoperative and postoperative voice recordings were compared. Endoscopic examination was done during follow-up periods to look for any complication (eg, edema, granulations, aspiration, and/or web formation).

**Statistical Analysis**

Patients who were candidates for the study agreed to participate and signed consent forms; they were randomly assigned to receive either LAPC or DAPC. Patients were assigned to treatment groups via a randomization scheme that ensured that equal numbers were assigned to each treatment.

In this study, all the surgical procedures were performed by the same surgeon (N.N.M.), while postoperative follow-up was carried out blindly by another otorhinolaryngologist (M.A.M.) and phonatrician (A.S.Q.). Data were analyzed using SPSS statistical software (version 14.0). Results of both groups were compared statistically using the following nonparametric tests because of the small numbers of patients in the study sample; χ² test was used to compare between qualitative data,

| Table 1. Pearson Scale for Evaluation of Aspirationa and Dyspnea Severity Scaleb |
|---------------------------------|---------------------------------|---------------------------------|
| **Description** | **Pearson Scale, Grade of Aspirationa** | **Dyspnea Category** | **Severity of Dyspnea** |
| Occasional cough but no clinical problem | 0 | None | 1 | None |
| Constant cough worsening with meals or swallowing | 2 | Dyspnea with mild limitation of daily activity | 3 | Moderate |
| Pulmonary complications | 3 | Dyspnea with severe limitation of daily activity, with stridor | 4 | Severe |
| Respiratory difficulty requiring tracheostomy | 5 | Very severe |

*aSee Pearson.75  
*bSee Dursun and Gokcan.14
and Mann-Whitney test was used for comparisons between quantitative data.

Results

This study included 20 patients, 4 men (20%) and 16 women (80%), who were diagnosed as having bilateral abductor vocal cord paralysis. Their ages ranged from 30 to 70 years (mean age, 50 years). Two patients (10%) had a tracheostomy in situ at the time of presentation. The vocal cords were immobile in all patients (Figure 1 and Figure 2).

The patients were categorized into 2 groups. Those in group A underwent LAPC and included 10 patients—4 men (40%) and 6 women (60%). Those in group B underwent DAPC and included 10 women. The mean age (SD) of group A was 53.5 (12.0) years, while that of group B was 51.1 (13.1) years. Thyroidectomy was noted as the cause of BVCP in all cases except in 1 case (5%) of a patient who had idiopathic etiology and was treated by LAPC. None of the patients in either group had symptomatic aspiration in the postoperative period or during follow-up.

Table 2 demonstrates comparison between group A and group B in the progress of dyspnea during the following periods: preoperative, 1 month, 6 months, and 1 year postoperatively. It was clear that preoperative comparison between group A and group B regarding the dyspnea category revealed a non-significant difference \((P \geq .05)\) between both groups, while all postoperative comparisons revealed significant differences \((P < .05)\). Comparison between the preoperative and 1-year postoperative dyspnea categories in each group revealed significant improvement in the dyspnea scores in both groups, because at the end of this study, there was improvement in the dyspnea scores of 9 patients of group A (90%) \((\chi^2 = 16.50)\) and of 5 of group B (50%) \((\chi^2 = 6.67)\).

Table 3 demonstrates comparisons between group A and group B in the preoperative and postoperative grade of dysphonia during the following periods: preoperative, 1 month, 6 months, and 1 year, which revealed that there was no significant difference between group A and group B for all com-
Comparison between preoperative and 1-year postoperative grades of dysphonia of the same group revealed nonsignificant difference in both groups ($\chi^2 = 0.12$ in group A and $\chi^2 = 1.67$ in group B). All postoperative LVSexaminations in both groups showed the area of absent mucosal glottic wave at the site of cordotomy, which was not improved by time.

Table 4 demonstrates preoperative and postoperative comparisons between patients in Group A and Group B in the acoustic analysis and Maximal Phonation Time (MPT). During acoustic comparisons, the 4 male patients were excluded because there are normal differences between the acoustic parameters of males and females that can affect the results. It showed nonsignificant differences in all comparisons except for MPT, which showed significant differences in all postoperative comparisons between both groups.

Table 5 demonstrates comparisons between preoperative and 1-year postoperative acoustic analyses and MPT in the same group. It revealed nonsignificant difference in all acoustic analyses except for $F_0$, which showed significant differ-
enous. The MPT also showed significant differences in both groups but with a higher difference in group A.

On the one hand, the postoperative complication of group B was early postoperative laryngeal edema, which necessitated postoperative intensive care unit (ICU) admission for all patients for 2 to 3 days. Inadequate airway and dyspnea occurred at 2 and 4 weeks, necessitating revision surgery in 2 patients. On the other hand, minimal laryngeal edema was present in LAPC cases, which needed only postoperative medical treatment in the form of corticosteroids, antibiotics, and mucolytic agents without the need for ICU admission.

Discussion

Bilateral vocal cord immobility is a challenging complication of the iatrogenic injury to both recurrent laryngeal nerves during thyroid surgery.16 Because both vocal cords are in a para- median position, the patient usually has little problem with voice, but sooner or later the airway will be compromised.17 A wide variety of surgical techniques are used to treat BVCP, with varying degrees of success. These include both external and endoscopic laryngeal surgical procedures. These procedures can be broadly categorized as dynamic and static. The results of dynamic procedures are controversial, so laryngologists are increasingly focusing on static ones.9

Most of these techniques have resulted in improvement of the airway at the sacrifice of an understandable speaking voice.7 At present, endoscopic cordotomy remains the most popular technique.18 In a further effort to provide an improved airway without significantly compromising vocal quality, Dennis and Kashima8 proposed the laser posterior partial cordotomy.

Twenty patients with bilateral abductor paralysis were enrolled in the study described herein. Patients were selected randomly for 2 different surgical procedures. In 10 patients, LAPC was performed (group A), and in 10 patients, DAPC (group B). Regarding dyspnea, there was a statistically significant difference in the results between both groups in favor of LAPC at the end of the postoperative evaluation (1 year after surgery). Both groups showed a statistically significant difference between preoperative and 1-year postoperative dyspnea category of the same group. This means that both techniques are effective in improving the airway.

Decannulation was achieved in all cases using laser equipment. This decannulation rate correlates well with rates reported in the studies by Rontal and Rontal9 and Manolopoulos et al.36 This decannulation rate is similar to the rate reported in the study by Hachiya et al,19 in which posterior cordotomy and partial arytenoidectomy was performed, and even our decannulation rate is higher than the rate detected with arytenoidectomy by Aubry et al.20

The high success rates of decannulation (100%) and dyspnea improvement (90%) in group A can be explained by the fact that the laser was used minimally, at low power, just enough to make linear posterior cordotomy, and this maneuver was associated with low thermal damage, which was followed by minimal, early postoperative edema as well as minimal, late postoperative fibrosis. This minimal postoperative edema was the key to successful decannulation, and the minimal fibrosis was the key to successful long-term results to this group.

Regarding DAPC, there was improvement in the dyspnea score in 50% of cases. These results contradict with those of the study by Aslam,21 which reported 75% improvement in dyspnea rate following DAPC. However, Aslam's rate21 correlates well with our early improvement rate (80% during the first 6 months after surgery), but does not correlate well with our late results (50% after 1 year after surgery). This discrepancy can be explained by the short period of follow-up in Aslam's study,21 as postdiathermy fibrosis is a slowly progressive process that can take as long as 1 year.22

The main postoperative complication of DAPC was laryngeal edema in the early postoperative phase, which necessitated postoperative ICU admission to all patients in group B for about 2 to 3 days. This added an extra cost to the surgery. Healing of the posterior wedge of the vocal cord by fibrosis started to appear about 2 to 4 weeks postoperatively, leading to less adequate airway and dyspnea in 5 cases; of these, 2 patients needed revision surgery to improve the airway.

The greater number of complications in group B (who underwent DAPC) in the form of early laryngeal edema is an in-

### Table 5. Comparison Between Preoperative and 1-Year Postoperative Acoustic Analysis and Maximal Phonation Time (MPT) in the Same Group of Patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Preoperative</th>
<th>1-y Postoperative</th>
<th>P Valuea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A (n = 10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F0</td>
<td>265 (25)</td>
<td>236 (21)</td>
<td>.01</td>
</tr>
<tr>
<td>Jitter, %</td>
<td>1.2 (0.5)</td>
<td>1.4 (0.5)</td>
<td>.39</td>
</tr>
<tr>
<td>Shimmer, %</td>
<td>5.19 (2.2)</td>
<td>5.1 (2.3)</td>
<td>.93</td>
</tr>
<tr>
<td>NHR</td>
<td>5.1 (1.2)</td>
<td>5.4 (3.0)</td>
<td>.77</td>
</tr>
<tr>
<td>MPT</td>
<td>9 (3.2)</td>
<td>27 (3.1)</td>
<td>.002</td>
</tr>
<tr>
<td>Group B (n = 10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F0</td>
<td>249 (19)</td>
<td>212 (27)</td>
<td>.002</td>
</tr>
<tr>
<td>Jitter, %</td>
<td>1.4 (0.4)</td>
<td>1.3 (0.9)</td>
<td>.75</td>
</tr>
<tr>
<td>Shimmer, %</td>
<td>5.3 (1.0)</td>
<td>6 (2.1)</td>
<td>.92</td>
</tr>
<tr>
<td>NHR</td>
<td>4.8 (1.1)</td>
<td>6.1 (1.7)</td>
<td>.57</td>
</tr>
<tr>
<td>MPT</td>
<td>7.6 (4.1)</td>
<td>14.9 (2.0)</td>
<td>.001</td>
</tr>
</tbody>
</table>

Abbreviations: F0, average fundamental frequency; NHR, noise to harmonic ratio.

*aBold font indicates statistical significance (P < .05).*
dication that diathermy is a less precise technique than LAPC and produces more thermal damage to the neighboring tissues, leading to early edema and late fibrosis.

Investigators in the field of diathermy attribute the damaging effects of the high-frequency current of diathermy to the production of heat within the neighboring tissues. Hemingway reported that the heating effect of diathermy takes place in an unpredictable depth of the tissues, an effect that is not present in LAPC.

It is generally believed that improved airway results in deterioration of voice quality. This view is not supported by the present study as there were no statistically significant differences between the 2 groups in preoperative comparisons and all postoperative comparisons.

Regarding voice assessment, the protocol of voice assessment used in our school comprises 3 levels. The first level contains subjective auditory assessment of the voice during many tasks (eg, counting and reading a standard passage); then auditory perceptual assessment of the grade of dysphonia is performed and rated using the GRBAS scale. In addition, visualization of the larynx is performed during this level. During the second level, documentation, the voice is rerecorded during the repetition of the same tasks, and the laryngeal image is recorded and photographed. During the third level of assessment, confirmation and follow-up, the changes in the quality of voice are confirmed by acoustic analysis of voice (eg, percentages of jitter and shimmer), as well as by aerodynamic measures that are related to respiratory functions during phonation. Among these measures, maximal phonation time was recorded and analyzed. Therefore, during our study we did not depend on only 1 line or 1 task for voice assessment. We used variable lines and tasks.

However, comparison between preoperative and 1-year postoperative grades of dysphonia in the same group revealed nonsignificant differences in both groups. Therefore, neither technique caused serious deterioration of the voice but led only to minimal vocal changes. This fact was confirmed by the comparison between preoperative and 1-year postoperative acoustic analysis, since most parameters showed also nonsignificant differences. The MPT that was shortened before surgery improved gradually in both groups (it was higher in group A) in the postoperative assessments. Comparison of the preoperative and 1-year postoperative MPT revealed that both techniques led to significant improvement of the respiratory support for voice production but with better results using the laser technique. The presence of significant difference in MPT, while the GRBAS assessment of the grade of dysphonia showed a non-significant difference, indicates that cordotomy does not worsen voice but improves respiratory functions, one of which is MPT.

In 90% of patients who underwent LAPC, postoperative voice remained the same as preoperative voice, whereas postoperative voice was worse in 1 patient (10%). All voice results were assessed according to the GRBAS scale, which gives a subjective measurement for the grade of dysphonia. The assessment then was confirmed by an acoustic analysis of the voice, which is an objective tool measuring a variety of voice parameters. They are measured automatically using a computerized system. We believe that by performing LAPC, the anterior and middle parts of vocal cords are preserved, resulting in airway improvement with good voice preservation. This opinion is shared by many other authors (eg, Manolopoulos et al and Friedman et al).

However, in 80% of patients who underwent DAPC, postoperative voice remained the same as preoperative voice, whereas postoperative voice was worse in 2 patients (20%). We believe that in DAPC, the anterior and middle parts of the vocal cords are preserved, resulting in good voice preservation. These results correlate well with those in the study of Segas et al. The worsening of voice in 2 patients of this group (20%) may be explained by the more stiffness of the vocalfold produced by fibrosis.

None of the patients who underwent LAPC or DAPC had symptomatic aspiration in the postoperative period and during follow-up, a result that is consistent with those of many studies (eg, Dursun and Gökcan, Aslam, and Harnisch et al). Probable reasons are that we preserved the arytenoids and that the surgical procedure was limited to cordotomy. In the study of Shvero et al, cordectomy with partial arytenoidectomy was performed, and 27.2% of patients experienced postoperative aspiration. Aubry et al found that 11.7% of patients who underwent laser arytenoidectomy had postoperative persistent aspirations (with pneumopathies in 1 case). This suggests that preservation of arytenoids prevents postoperative aspiration problems.

In conclusion, LAPC can be considered a reliable and superior procedure compared with DAPC in the treatment of bilateral vocal cord abductor paralysis. The distinct advantage of this technique is the better postoperative airway with minimal complications.

**ARTICLE INFORMATION**

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Study concept and design: Mohamed, El-Anwar, Quriba.

Acquisition of data: Mohamed, Sorour, El-Anwar.

Analysis and interpretation of data: All authors.

Drafting of the manuscript: All authors.

Critical revision of the manuscript for important intellectual content: Mohamed, El-Anwar, Quriba, Mahdy.

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Administrative, technical, and material support: El-Anwar, Quriba.

Study supervision: Mohamed, Sorour.


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