Endoscopic Partial Arytenoidectomy for Bilateral Vocal Fold Paralysis: Medially Based Mucosal Flap Technique

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Summary: Purpose. Endoscopic partial arytenoidectomy (EPA) is one of the static operations for treatment of bilateral vocal fold paralysis (BVFP). Improvement in airway may cause voice loss and aspiration. The author reports his experience on EPA using medially based mucosal flap to enlarge posterior glottis without removing any part of membranous vocal fold.

Materials and Methods. Sixty-four consecutive patients with BVFP underwent EPA. Pre- and postoperative evaluations included Voice Handicap Index-30, aerodynamic and acoustic analysis, flow volume loops, perceptual evaluation of pre- and postoperative voice using grade, roughness, breathiness, asthenia, strain (GRBAS) scale, speech intensity, breathing ability evaluation, and functional outcome swallowing scale.

Results. Nine patients had preoperative tracheotomy and one patient required postoperative tracheotomy. All tracheotomized patients were decannulated 1 month after surgery. Fifty-six patients (88%) did not report dyspnea in their daily activities and were considered satisfied with their postoperative airway; eight patients required revision: seven total arytenoidectomy and one posterior cricoid split with costal cartilage grafting. All Voice Handicap Index-30 results and all acoustic results (except fundamental frequency) increased significantly after surgery ($P < 0.05$). All aerodynamic analysis results (except mean airflow rate) decreased significantly after EPA ($P < 0.05$). Mean airflow rate increased significantly after EPA ($P < 0.05$). All flow volume loop parameters increased significantly after EPA ($P < 0.05$). Perceptual comparison of pre- and postoperative voice revealed similar grade and roughness ($P > 0.05$); however, increased breathiness ($P < 0.05$) was observed. Mean speech intensity decreased from 67 dB to 61 dB ($P < 0.05$). Postoperative breathing ability was significantly better. Pre- and postoperative functional outcome swallowing scales were not significantly different ($P > 0.05$).

Conclusions. EPA is a very successful static surgical option for BVFP. It results in comfortable airway with mild voice handicap. Postoperatively, it does not increase aspiration significantly. Endoscopic total arytenoidectomy is reserved for revision of failures.

Key Words: Vocal cords−Vocal cord paralysis−Arytenoid cartilage−Laryngoscopy−Laryngeal diseases.

INTRODUCTION

Bilateral vocal fold paralysis (BVFP) is a life-threatening health problem. It results in airway obstruction, aspiration, swallowing disturbance, and voice change. It develops most commonly after thyroidectomy, especially revision thyroid surgery; the next most common causes are neoplasms.[1,2] Among many treatment options for BVFP, posterior cordotomy and arytenoidectomy are most frequently emphasized as permanent laterofixation methods.

Endoscopic total arytenoidectomy was defined in the 1940s.[3] There were claims that total arytenoidectomy led to aspiration problems postoperatively and disturbed voice significantly.[4,5] In the traditional endoscopic total arytenoidectomy, after removal of arytenoid cartilage with cold instruments, its bed is cauterized with electrocautery and is left to secondary scar contracture.[3−7] Alternatively, arytenoid cartilage together with its overlying mucosa is evaporated using CO_2 laser; the resulting charred open wound has to epithelialize by secondary intention. Scarred surgical area does not have sensation, because its nerves were burned during the previous operation.[6,7] Therefore, aspiration appears consequently. Furthermore, loss of arytenoid height may facilitate hypopharyngeal secretions to flow into laryngeal lumen. Lack of mucosal sensation together with loss of arytenoid height may make aspiration problem even worse.

Endoscopic partial arytenoidectomy and posterior/transverse cordotomy have become more popular recently because of the abovementioned potential aspiration risk after total arytenoidectomy. However, a study concluded that by preserving arytenoid mucosa, rather than burning it with CO_2 laser, and using it as a medially based flap and suturing it laterally, one can attain large enough glottis for ventilation and risk of aspiration is not as high as expected.[8]

The aim of this study was to present pre- and postoperative airway, swallowing, and voice parameters with both objective and subjective methods after EPA. This study was carried out to analyze data in order to augment experience about airway, swallowing, and voice results after EPA.

MATERIALS AND METHODS

Sixty-four otherwise healthy, consecutive patients with BVFP who were operated on by EPA using mucosal advancement flap and permanent vocal fold lateralization

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Conflict of interest: The author owns the patent for the laryngoscope for posterior laryngeal procedures.

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by microsuture between 2011 and 2015 were included in the study (Figures 1−7).

This study was approved by the ethics committee of our university (number GO 15/18).

The study group included 8 men and 56 women. Their ages ranged between 24 and 80 with a mean of 52 and standard deviation of 12.4. Etiology of BVFP was thyroidectomy on 60 patients; cerebellar ataxia, idiopathic, neurofibromatosis type 2, and tracheal resection on 1 patient each. Nine patients had preoperative tracheotomy and one patient required postoperative tracheotomy.

Preoperative evaluations included Voice Handicap Index (VHI-30), including physical, functional, emotional, and total scores; aerodynamic analysis using Kaypentax Phonatory Aerodynamic System Model 6600 (Kaypentax, Montvale, NJ), including maximum phonation time (seconds), mean flow rate (L/s), mean resistance ($cmH_20/L/s$), mean power (W), mean efficiency (ppm), and mean pressure (cmH_2O); acoustic analysis with sustained phonation using /a/ at comfortable pitch and loudness by using *Computerized Speech Lab Model 4500* (CSL, Kaypentax), including fundamental frequency (Hz), absolute jitter (Jita, μs), shimmer percent (%), and noise-to-harmonic ratio; respiratory function tests with a spirometer (Jaeger APS Pro Spirometry device, CareFusion, San Diego, CA), including the ratio of forced expiratory volume in 1 second (%), forced vital capacity (%), peak expiratory flow (%), forced inspiratory volume in 1 second (L), and peak inspiratory flow (L/s); perceptual evaluation of pre- and postoperative voice by a phoniatrician using grade, roughness, and breathiness of GRBAS (grade, roughness, breathiness, asthenia, strain) scale (0−3); speech intensity on sustained phonation with /a/ using Voice Range Profile of *CSL Model 4500* (Kaypentax); using head microphone having a 10-cm microphone-to-mouth distance; self-evaluation of breathing ability by the patient on a scale of −2 to +2 (−2: significantly worse; −1: somewhat worse; 0: no change; +1: somewhat better; +2: significantly better); and functional outcome swallowing scale (FOSS): 0−5.[9]

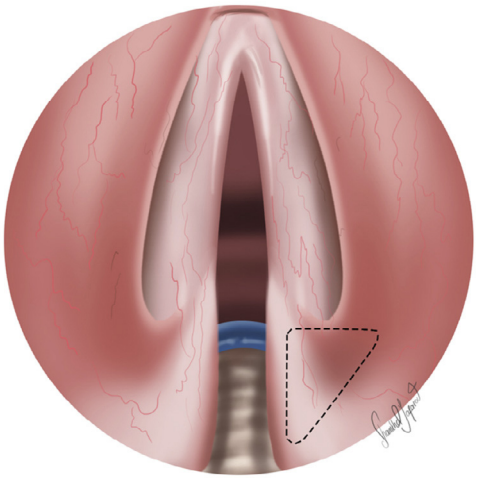

FIGURE 1. Anteriorly based triangular mucosa on right arytenoid will be incised with CO_2 laser.

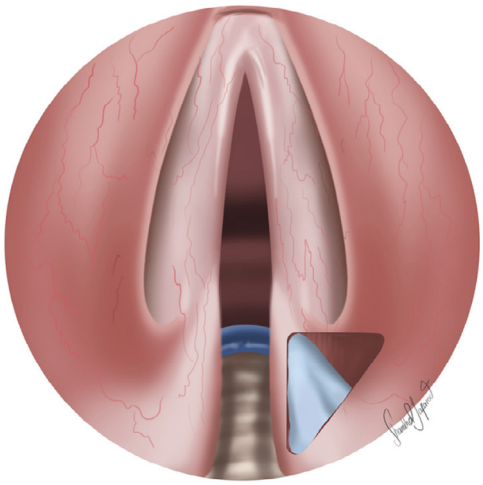

FIGURE 2. After removal of mucosa, vocal process and body of right arytenoid cartilage were exposed.

All patients were informed about 1%−2% risk of postoperative tracheotomy, and written informed consent was taken from each patient. Every patient was followed up every 2 months up to 1 year, then yearly. Preoperative examinations were redone 12 months after surgery. During examinations before 12 months, only endoscopy of the larynx was performed. Minimum follow-up was 1 year and mean follow-up was 2 years.

Surgical technique

The patient is intubated orally with armored intubation tube (5.0- to 6.5-mm internal diameter), which is fixed to the corner of the mouth opposite to the side of arytenoid to be operated on. The surgeon manipulates the intubation tube with his index finger to place the tube into the canal on top of the tip of laryngoscope as he introduces the laryngoscope (no commercial name yet, produced by Storz catalog number 8590 YL, Tuttlingen, Germany) through the mouth[10](Figure 8). As the tip of laryngoscope reaches the arytenoid, the intubation tube will be elevated anteriorly in the glottis, leaving posterior glottis empty for surgical maneuvers. After placing the laryngoscope tip around the arytenoid to be extracted, an anteriorly based triangular mucosal incision is marked with laser spots. Mucosal incision was done using CO_2 laser at 5 W, smallest spot size available, and continuous mode down until arytenoid cartilage is visualized. This triangular mucosa is excised and removed (Figures 1 and 2). Using laryngoscopic scissors, vocal process and anterior half of body of arytenoid cartilage is dissected off the surrounding tissues. Vocal process of arytenoid is cut from membranous vocal fold by scissors. During dissection of arytenoid, mucosa medial to arytenoid is cautiously protected to be used later as an advancement flap. Right in the middle of arytenoid cartilage, a transverse cut is done with CO_2 laser until the lower border of cartilage is reached; the remaining cartilage contacts is cut with straight large scissors. The anterior half of arytenoid cartilage is extracted with forceps (Figure 3). On the protected mucosa medial to arytenoid, a vertical mucosal cut is done right behind the membranous vocal fold toward subglottis using straight microscissors

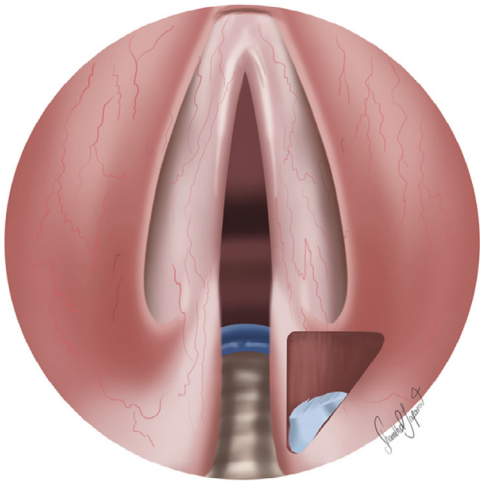

FIGURE 3. Vocal process and anterior half of body of right arytenoid cartilage was taken out.

(Figure 4). This cut produces posteroinferiorly based mucosal advancement flap. This flap will be sutured to the lateral wall of surgical wound to enlarge the posterior glottis (Figure 5). One to three 5/0 vicryl sutures with 11-mm long, curved, reverse cutting needle are done between the anterior edge of mucosal flap and lateral surgical bed (Figure 6). To facilitate the performance of these sutures, the intubation tube has to be elevated from posterior commissure up toward anterior commissure and kept there by a special laryngoscope with a superior groove.[10] Otherwise, suture needle cannot be inserted between the intubation tube and mucosal flap; without this suture on mucosal advancement flap, enlargement of posterior glottis will be left to chance by mucosal lateralization secondary to scar contracture of surgical bed and will therefore be very limited; success of arytenoidectomy will diminish. Once the advancement flap is sutured, surgery at the posterior glottis is over, and there is no need for elevation of intubation tube anteriorly; therefore, the laryngoscope with a canal on top of

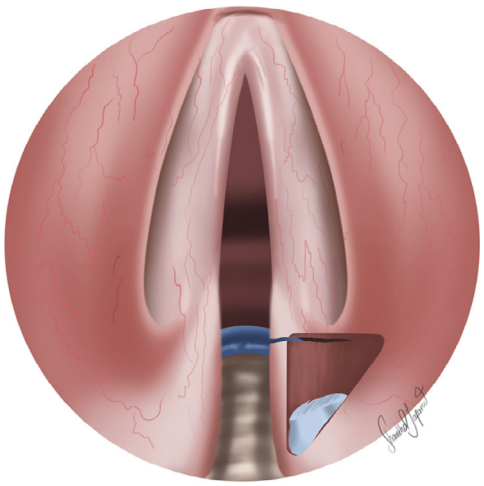

FIGURE 4. Mucosa medial to arytenoid was incised right at the posterior end of membranous vocal fold, and medially based advancement flap was outlined.

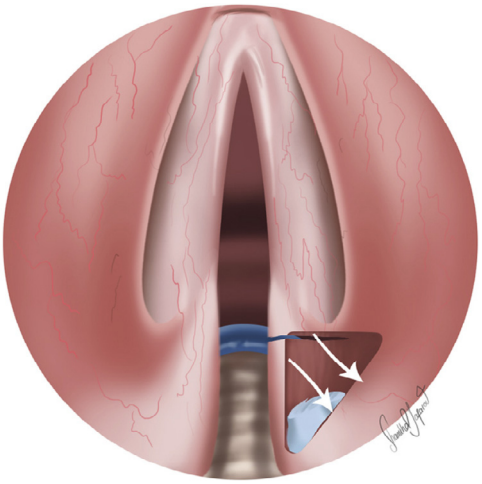

FIGURE 5. The directions of lateralizing sutures were demonstrated.

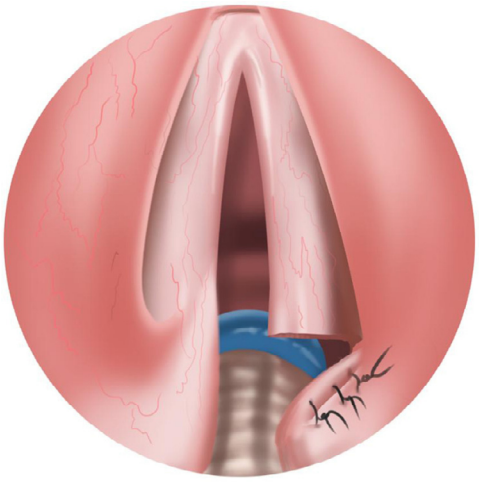

FIGURE 6. The medially based advancement flap was sutured laterally.

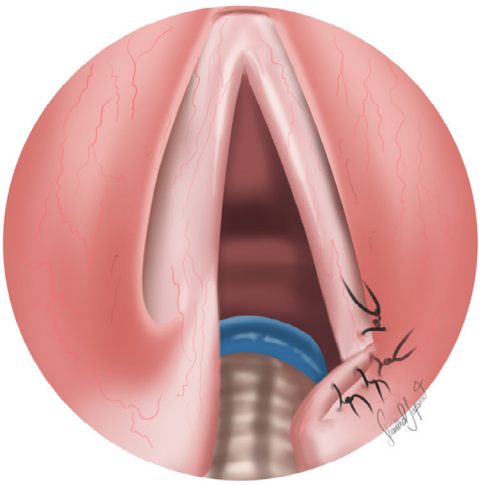

FIGURE 7. Membranous vocal fold was sutured posterolaterally.

FIGURE 8. Laryngoscope used for arytenoidectomy.

its tip is removed and replaced with a regular laryngoscope (Kleinsasser, Storz, Tuttlingen, Germany). Then the membranous vocal fold is sutured posterolaterally permanently by two to three 5/0 vicryl sutures with 11-mm long, curved, reverse cutting needle to the aryepiglottic fold right lateral to the previous advancement flap suture, thus tensing and lateralizing the vocal fold (Figure 7). Use of single suture is avoided because suture may cut through tissue postoperatively, leaving the vocal fold free in the airway; in such a situation, the patient will have serious voice loss. Thus, two to three sutures will keep the vocal fold lateralized and tensed. This vocal fold suture will minimize postoperative voice loss. These sutures bring mucosa toward surgical bed and cover bare areas with mucosa, thus decreasing the risk of granulation tissue formation postoperatively. Posterior commissure mucosa should not be traumatized by laser or cold instruments to prevent posterior glottic stenosis[6,8,10,11] (Intraoperative Video). The duration of surgery is 45−60 minutes. The anesthesiologist injects 250-mg methylprednisolone intravenously as a single dose during surgery to decrease the risk of possible laryngeal edema. The patient is hospitalized two nights in an otolaryngology ward for follow-up; he inhales cold water vapor during his hospital stay and oral analgesics are given on demand. Antibiotics and antireflux medications are not ordered.

The significance was taken as $P < 0.05$. For comparisons of preoperative and postoperative results of scale variables, Student t test for paired samples was used. For similar comparisons of ordinal variables, McNemar-Bowker test was utilized for m × n tables.

Ten patients had unilateral posterior cordotomy; one patient had bilateral posterior cordotomy elsewhere before; they applied to our department because of continuing dyspnea. Another patient with BVFP had fat injection for correction of dysphonia elsewhere; she became dyspneic afterward and applied to our department for further treatment. Three of 10 patients with unilateral posterior cordotomy also had temporary external suture lateralization. Fifty-two patients were primary (unoperated) cases.

RESULTS

Nine patients had preoperative tracheotomy and one patient required postoperative tracheotomy because of airway edema. All 10 tracheotomized patients were decannulated 1 month after surgery. There were two cases of postoperative granuloma formation; they disappeared spontaneously without treatment.

Fifty-six (88%) patients had satisfactory airway after partial arytenoidectomy; eight patients required revision: seven total arytenoidectomy and one posterior cricoid split with costal cartilage grafting. The patients were dyspnea-free after revision surgery. The cause of failure was insufficient lateralization of the membranous vocal fold. Satisfactory airway meant that the patient could perform daily activities without respiratory distress (walk, climb up the stairs, exercise, go shopping, perform household work, and continue working). If any of the above was mentioned by the patient that he or she could not do, then airway was considered unsatisfactory and revision was planned.

The comparison of pre- and postoperative VHI-30 results are shown in Table 1. All VHI-30 results increased significantly after EPA ($P < 0.05$). According to the total VHI results, patients' voices became mild voice handicap after EPA.

The comparison of pre- and postoperative aerodynamic analysis results are given in Table 2. All aerodynamic analysis results, except mean airflow rate, decreased significantly after EPA ($P < 0.05$). Mean airflow rate increased significantly after EPA ($P < 0.05$).

The comparison of pre- and postoperative acoustic analysis results are demonstrated in Table 3. All acoustic results (except fundamental frequency) increased significantly after EPA ($P < 0.05$). Fundamental frequency did not change significantly after EPA ($P > 0.05$).

Comparisons of perceptual evaluation of pre- and postoperative voice are demonstrated in Table 4. Grade and roughness of voice did not change significantly postoperatively ($P > 0.05$); however, breathiness of voice increased significantly postoperatively ($P < 0.05$).

TABLE 1.
The Comparison of Pre- and Postoperative VHI-30 Results (Student *t* Test for Dependent Samples)

	Preoperative	Postoperative	*t*	*P*
VHI-physical	11.10 ± 4.77	14.88 ± 7.22	2.095	0.02
VHI-functional	9.92 ± 4.76	13.52 ± 5.88	2.38	0.01
VHI-emotional	6.44 ± 3.89	7.65 ± 4.02	1.99	0.025
VHI-total	27.46 ± 13.42	36.05 ± 17.12	3.22	0.001

TABLE 2.
The Comparison of Pre- and Postoperative Aerodynamic Analysis Results (Student *t* Test for Dependent Samples)

	Preoperative	Postoperative	*t*	*P*
Maximum phonation time	6.24 ± 3.13	5.01 ± 2.22	1.99	0.025
Mean airflow rate	0.18 ± 0.03	0.24 ± 0.05	2.65	0.005
Mean resistance	105.34 ± 32.09	50.09 ± 26.85	3.45	0.0005
Mean power	0.08 ± 0.03	0.05 ± 0.02	2.91	0.0025
Mean efficiency	61.05 ± 27.72	51.38 ± 29.51	2.38	0.01
Mean pressure	3.51 ± 1.26	4.87 ± 1.38	2.09	0.02

Preoperative mean speech intensity on continuous /a/ was 67 dB and postoperative mean speech intensity was 61 dB. This difference was statistically significant ($t = 2.09$; $P = 0.02$).

Postoperative breathing ability was evaluated as +1 (somewhat better) by 3 patients (4.7%) and +2 (significantly better) by 61 patients (95.3%). The mean was +1.95, indicating significantly better postoperative breathing ability.

The preoperative FOSS was "0" in 17 patients, "1" in 37, and "2" in 10. The postoperative FOSS was "0" in 15 patients, "1" in 37, and "2" in 12. There was no statistically significant difference between pre- and postoperative

TABLE 3.
The Comparison of Pre- and Postoperative Acoustic Analysis Results (Student *t* Test for Dependent Samples)

	Preoperative	Postoperative	*t*	*P*
Fundamental frequency	210.5 ± 63.8	227.2 ± 72.1	0.679	0.25
Jita	102.9 ± 41.8	218.1 ± 90.4	3.45	0.0005
Shim	5.01 ± 3.45	8.27 ± 3.34	2.89	0.0025
NHR	0.07 ± 0.03	0.15 ± 0.05	3.22	0.001

Abbreviation: NHR, noise-to-harmonic ratio.

TABLE 4.
Comparisons of Perceptual Evaluation of Pre- and Postoperative Voice Using GRBAS Scale (McNemar-Bowker Test)

		Postoperative Grade				
		0	1	2	3	Statistics
Preoperative grade	0	2	5	1	0	McNemar-Bowker = 7.87, $P = 0.16$
	1	6	6	18	4	
	2	0	7	7	4	
	3	0	1	3	0	

		Postoperative Roughness				
		0	1	2	3	
Preoperative roughness	0	1	7	2	0	McNemar-Bowker = 7.49, $P = 0.19$
	1	4	21	10	1	
	2	1	2	6	3	
	3	0	3	3	0	

		Postoperative Breathiness				
		0	1	2	3	
Preoperative breathiness	0	4	7	3	0	McNemar-Bowker = 19.72, $P = 0.001$
	1	2	14	15	4	
	2	0	2	5	3	
	3	0	0	3	2	

Abbreviation: GRBAS, grade, roughness, breathiness, asthenia, strain.

TABLE 5.
The Comparison of Pre- and Postoperative Respiratory Function Test Results (Student *t* Test for Dependent Samples)

	Preoperative	Postoperative	*t*	*P*
PEF (%)	36.1 ± 9.3	62.6 ± 8.8	2.90	0.0025
FEV_1 (%)	60.2 ± 10.4	83.2 ± 11.1	2.65	0.005
FVC (%)	83.1 ± 11.6	96.6 ± 12.7	2.38	0.01
PIF (L/s)	1.0 ± 0.3	2.4 ± 0.4	3.22	0.001
FIV_1 (L)	0.8 ± 0.2	2.1 ± 0.3	3.45	<0.001

Abbreviations: FEV_1, forced expiratory volume in 1 second; FIV_1, forced inspiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow; PIF, peak inspiratory flow.

swallowing (McNemar-Bowker = 4.00; $P = 0.135$). Swallowing scale increased from "0" to "2" in two patients only. None of the patients were hospitalized for aspiration; none required nasogastric tube or gastrostomy tube feeding.

The comparison of pre- and postoperative respiratory function test results are outlined in Table 5. All parameters increased significantly postoperatively ($P < 0.05$).

DISCUSSION

Many surgical procedures have been defined for the treatment of BVFP; many because none is an ideal solution for problems of BVFP. None appears to be superior to others. Laryngologists are still in search for better alternatives. These procedures can be briefly classified as static versus dynamic. Static techniques are based on tissue resection and enlargement of glottic airway, and they present the treatment of choice today; however, their end-result is unphysiologic because voice is sacrificed for a better airway.[12]

Because posterior glottis is more dedicated to respiration, resections are mostly done in the posterior glottic area, and excision in the posterior glottis leaves the membranous vocal folds, which are mainly phonatory and undamaged.[8] A critical point in all glottis-enlarging static operations is the optimal amount of vocal fold tissue resected, in order to achieve enough glottic airway and still an acceptable voice.[12,13] This is especially true for posterior cordotomy, which is probably the most frequently performed surgical procedure for BVFP.

However, the future of BVFP surgery will be dynamic procedures, such as reinnervation, pacemaker, stem cell therapy, etc. There has to be further development in these areas for them to be accepted as the treatment of choice.

Endoscopic total arytenoidectomy is a traditional procedure for BVFP, defined in the middle of the 20th century.[3] However, partial arytenoidectomy techniques have a better reputation nowadays. They are claimed to attain good airway with better voice preservation and less aspiration compared with total arytenoidectomy. However, a recent study determined that there was no difference between partial and total arytenoidectomy in terms of voice, airway, and aspiration.[8] Partial arytenoidectomy is as successful as total arytenoidectomy in enlarging glottal airway because vocal process and anterior body of arytenoid are located within laryngeal lumen, not the posterior body of arytenoid. Furthermore, preservation of arytenoid height may be protective against aspiration of hypopharyngeal contents. However, laser must be used only during partial arytenoidectomy to cut through the body of arytenoid, but not during total arytenoidectomy. Laser use brings higher precision, less bleeding, higher cost, and laser-related potential complications.

Crumley[14] introduced endoscopic laser medial arytenoidectomy. He resected the medial part of the arytenoid body and preserved its lateral, posterior, and inferior aspects and vocal process. He aimed to preserve the phonatory vocal folds. Bosley et al[15] pointed that medial arytenoidectomy enlarged the posterior glottis without significantly affecting the membranous vocal fold, resulting in a minimal adverse effect on voice. Young and Rosen[16] commented that medial arytenoidectomy continued to seek improvement in dyspnea symptoms with minimal decline in voice and/or swallowing function and high decannulation rates and that postoperative dysphagia appeared to be less commonly observed. Hillel et al[17] performed medial arytenoidectomy by destroying the vocal process and medial arytenoid cartilage to create more space posteriorly. They combined posterior cordotomy with medial arytenoidectomy. However, Crumley[14] and Gorphe et al[18] indicated that medial arytenoidectomy left intact the attachment of the vocal fold to the vocal process; thus, the anatomic position of the fold was not distorted and the membranous glottis was left intact. Although Gorphe et al[18] specified that they preserved vocal process, the picture they published clearly showed that vocal process was indeed removed. Therefore, the comment that the amount of tissue removed during static procedures can be variable might be true. Furthermore, medial arytenoidectomy is performed by removing the overlying mucosa by laser; its surgical bed is left to granulation and secondary healing by epithelialization. This carries the potential risk of granuloma formation and posterior glottic stenosis. The author believes that elevating mucosa and preserving it to cover arytenoidectomy defect with it would be a better surgical technique.

Arytenoidectomy is generally performed by removing arytenoid cartilage together with its overlying mucosa. This technique carries the risk of granuloma and scar formation, because a raw surface in the larynx may cause excessive scar formation and scar contracture. This scar may lead to re-narrowing of the airway because surgical defect is not covered with mucosa. These may occur early or many years after surgery.[12] However, by using mucosal advancement flap and suturing the membranous vocal fold posterolaterally, all raw surfaces are covered with neighboring mucosa and there is minimal granuloma and scar formation. In this study there were two cases of early granuloma formation during follow-up; these granulomas disappeared spontaneously without treatment.

Probably the most commonly performed operation for BVFP in the world is the posterior cordotomy introduced by Dennis and Kashima[4] in 1989. Here, a V-shaped wedge of the posterior vocal fold is excised from the free border, extending laterally toward thyroid cartilage. The rationale

of this procedure lies in the release of the tension of the glottic sphincter together with the removal of glottic tissue. After cordotomy, the remaining membranous vocal fold contracts anteriorly and stays lax there because of the tension in vocal ligament and vocalis muscle leading to V-shaped glottic enlargement. However, 30%–60% of the patients needed bilateral or more than one consecutive intervention, because initially large cordotomy defect will be filled by granulation tissue and scar tissue. These will eventually obliterate cordotomy defect.[4] Failures after cordotomy are due to granulations or to the formation of the scarred vocal fold, which may also be called pseudocord, as it appears after cordectomy for cancer resections. This pseudocord represents a fibrous scar stretching from the anterior commissure to the arytenoid and it tends to stay in the median position.[12]

Kashima[5] performed a transverse incision just anterior to vocal process, resulting in retraction of the anterior part of the thyroarytenoid muscle, so a V-shaped widening in the posterior glottic airway occurred together with increase of the vocal fold mass in the anterior glottis. He claims that it results in better voicing; however, lax and nonvibrating vocal fold results in loss of voice. The surgeon only destroys voice by removing any part of the membranous vocal fold and making it lose its tension. Voice can be preserved only by keeping intact the structure and tension of the membranous vocal fold. Isshiki[19,20] described the length, elasticity, and mass of the vocal fold as the main outcomes during phonosurgery. Therefore, the preservation of the vocal fold's structural integrity and tension is beneficial for postoperative voice production.[21] Szakács et al[21] determined in their study on cadaver larynges that transverse cordotomy led to the shortest vibrating length of the vocal fold among other glottis-enlarging procedures, and that arytenoidectomy caused insignificant changes in vibrating length of the vocal fold.

According to the results of this study, partial arytenoidectomy did not result in significant increase in postoperative aspiration and swallowing problems because these patients aspirated because of denervated larynx and not because of arytenoidectomy. The majority of patients are post-thyroidectomy cases and their internal branch of superior laryngeal nerve is intact. The intact internal branch of superior laryngeal nerve is the key factor protecting the patient against aspiration. The patient with high vagal lesions tends to aspirate more because of lack of protection of internal branch of superior laryngeal nerve. Making a posterior incision for arytenoidectomy is another key to preventing damage to internal branch of superior laryngeal nerve and aspiration. Making a more anterior incision may disrupt internal branch of superior laryngeal nerve entrance into supraglottis.

Preserving the membranous vocal fold is necessary but not enough for voice preservation; preservation of tension of vocal fold is required, which can be done by suturing the membranous vocal fold posterolaterally after arytenoidectomy. This maneuver both lateralizes and tenses the membranous vocal fold, thus preserving voice. If the membranous vocal fold is left loose anteriorly, there will be excessive voice loss. Too much lateralization is detrimental to voice and should be avoided. Thus, the surgeon will determine how much lateralization the patient needs and will fix the vocal fold where he thinks it is best for the patient; therefore, he will not leave the vocal fold loose and its lateralization to chance by scar contracture. This can be performed by preserving mucosa around arytenoid and suturing it as a flap laterally.

Plouin-Gaudon et al[22] described subtotal arytenoidectomy and claimed that its great advantage lies in the fact that it maintains rigidity along the posterior arytenoid frame and prevents inward collapse of mucosa and decreases the risk of aspiration. The comment on aspiration is their opinion, and not based on evidence.

Sapundzhiev et al[12] claim that the most serious complication of the endolaryngeal total arytenoidectomy is aspiration caused by the lowering of the aryepiglottic fold. They advise that total arytenoidectomy be avoided or subtotal arytenoidectomy performed using only techniques that preserve the medial mucous membrane part of the arytenoid cartilage. Their beliefs on aspiration being caused by total arytenoidectomy are not based on evidence. In previous studies, it was shown that total arytenoidectomy itself did not cause aspiration.[6,8,11]

Both partial and total arytenoidectomy provide comparable airway, voice, and swallowing postoperatively.[8] However, partial arytenoidectomy has a longer surgical duration than total arytenoidectomy. Preserving overlying healthy mucosa is a key for success of arytenoidectomy, whether partial or total. Preserving mucosa means preserving sensation and less aspiration, because the internal branch of superior laryngeal nerve is intact in most of these patients. Burning mucosa and submucosal tissues with laser or electrocautery is not a sound surgical technique because it will lead to uncontrolled scar tissue without sensation; therefore, preserving healthy mucosa should be the aim of the surgeon. Lack of sensation predisposes a patient to aspiration and scar tissue and may cause restenosis of glottis and supraglottis with poor postoperative airway.[8]

Preserving the membranous vocal fold and suturing it posterolaterally permanently lateralizes and tenses the vocal fold, thus preserving voice while also enlarging the glottis. Most patients end up with a mild voice handicap. No piece of true and false vocal fold is removed in this technique. The assertion of preserving voice by removing a part of the membranous vocal fold is far from outdated.

In case of revision after unsuccessful partial arytenoidectomy, total arytenoidectomy is required, which was successful in seven out of seven cases. Revision after failed total arytenoidectomy would require microtrap door flap. Microtrap door flap surgery involves elevating mucosa of the stenotic segment, removing fibrotic tissues with laser, then laying elevated mucosa back toward deeper tissues and suturing it.[23] If microtrap door also fails, then posterior cricoid split + costal cartilage grafting would be necessary. During revision surgery, the membranous vocal fold may be sutured permanently laterally, instead of posterolaterally, to gain improved airway; however, in such a situation, airway will be improved in expense of loss of voice. This is practiced only after failed previous operations but not in primary cases.

Loss of arytenoid height is one disadvantage of total arytenoidectomy. This is preserved in case of partial arytenoidectomy. Another advantage of partial arytenoidectomy is that it provides a chance for revision with high likelihood of success if the primary operation fails; in such a case you can easily perform total arytenoidectomy as a revision. However, after failed total arytenoidectomy, the revision operation requires microtrap door flap technique and is technically very difficult and less likely than the primary operation to be successful. Therefore, it may be a sound practice to perform partial arytenoidectomy initially to primary BVFP cases and reserve total arytenoidectomy for revision cases.[8,11]

The results of this study revealed that EPA resulted in significant improvement in respiratory parameters (inhaled and exhaled air volumes and their rates); however, it also ended in significant worsening of acoustic and aerodynamic parameters, indicating significant worsening of voice and valve function of glottis. It did not cause significant change in grade and roughness of voice; however, it caused significant increase in breathiness of voice. According to VHI results, preoperative voice turned into mild voice handicap postoperatively; therefore, it may not be a good surgical choice for a voice professional. Furthermore, it did not lead to a significant worsening of swallowing.

CONCLUSIONS

EPA by preserving surrounding mucosa and using it as a flap to enlarge the airway is a very successful static surgical option for treatment of BVFP. It results in enough postoperative airway and mild voice handicap. It does not cause significant worsening of swallowing. Failures can be revised with total arytenoidectomy.

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at doi:10.1016/j.jvoice.2018.04.007.

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