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Main Article

Changes in ventilatory function following surgery for bilateral abductor paralysis

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Abstract Management of bilateral vocal fold immobility continues to remain a challenge for the Otolaryngologist who attempts to create a balance between creation of an adequate airway and preservation of voice. The flow volume loop obtained by spirometry provides an ideal objective assessment tool to evaluate the results of surgery for this condition. Our experience in using peak inspiratory flow rate (PIFR) and forced inspiratory flow with 50% of vital capacity (FIF_{50}) in the lung in assessing the results of surgery is described. Seventeen patients were included in the study. The surgical procedures performed included laser posterior cordectomy with partial arytenoidectomy, endoscopic arytenoidectomy and posterior cordectomy-Kashima's technique. Twelve out of 17 patients were successfully decannulated, a success rate of 70.6%. All patients except one showed an increase in mid-inspiratory flow rates and peak inspiratory flow rates. The mean increase in FIF_{50} was 0.44 l/sec (52.6%) and the mean increase in PIFR was 0.41l/sec (39.77%). No statistically significant difference in improvement of inspiratory flow rates was observed between the three surgical procedures used in the study.

Keywords Vocal cord paralysis · Pulmonary function tests · Bilateral abductor paralysis

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Introduction

Bilateral vocal fold immobility with the true cords in paramedian position results in severe airway compromise at rest or on exertion with a relatively unaffected voice. Although the initial step in management is to safely bypass the obstruction through a tracheostomy, this is only a temporary measure because of the obvious difficulties in the long-term management of a tracheostomized patient. The next step continues to remain a challenging proposition for an Otolaryngologist who aims at avoiding the discomfort of a permanent tracheostomy tube for the patient and providing an adequate natural airway. There are several options described ranging from options as simple as a ventriculocordectomy by Chevalier Jackson [1] in 1922 as a glottis widening procedure, to as complex as reanimation of the larynx with a an electrical device [2]. A number of external and endoscopic surgical procedures [1–6] have been described to achieve a perfect balance between the airway and voice preservation.

Most of the earlier studies were hindered by the lack of objective parameters to gauge the results of surgery. The only criterion to evaluate these surgical procedures was the percentage of patients who could be decannulated [5, 7]. The flow volume loop obtained by spirometry, provides a reliable objective assessment of the upper airway and this tool has been effectively used by otorhinolaryngologists as a parameter to evaluate the improvement in airway following surgery for bilateral vocal fold immobility [2, 6, 8].

In this study, an attempt has been made to objectively evaluate and compare the efficacy of three different surgical procedures well described in literature. The techniques compared included laser posterior cordectomy with partial arytenoidectomy [2], endoscopic arytenoidectomy and posterior cordectomy-Kashima's technique [5].

Materials and methods

Seventeen patients of bilateral abductor palsy presented to ENT OPD from July 2001 to December 2004. The patients underwent a detailed history and clinical examination in order to confirm the diagnosis and to determine the etiology of vocal cord palsy. CECT (base of skull to chest) was done in selected patients in whom the etiology was undetermined after routine investigations.

All surgical procedures were performed by using suspension microlaryngoscopy. Either a Zeiss operating microscope or a Leica microscope with a 400 mm objective lens was used in all cases. The microscope was coupled to the CO_2 laser when required.

The patients were followed up at an interval of 1, 3 and 6 months following surgery.

Evaluation of results

Surgical outcomes were assessed in terms of airway and speech.

Functional assessment of upper airway

This was done by pulmonary function tests in the respiratory medicine laboratory of the Department of Medicine. If the patient had been tracheostomized, prior to presentation, the tracheostomy tube was removed and the stoma was tightly strapped before conducting the test. The upper airway was dynamically assessed by measuring airflow at different lung volumes in liters per second [flow volume loop]. To generate a loop, a patient was instructed to take in a slow deep breath to total lung capacity (TLC) and then breathe out as fast and as far as possible to residual volume and then breathe in as fast as possible back to total lung capacity. A flow volume loop was thus obtained wherein; flow was displayed on vertical axis.

Following parameters were considered relevant:

A) PIFR
B) FIF_{50}

The test was conducted three times and the maximum values obtained from the three technically satisfactory methods were considered. The values thus obtained were compared with the predicted values for a normal person of the same sex, height and weight as that of the patient. The percentage of the observed value in relation to the predicted value was obtained. The above findings were analysed to determine type of obstruction.

Voice analysis

The voice of the patients was graded subjectively by a speech pathologist based on a 5-point scale devised by Koufman et al. (1986) [9].

1-normal; 2-nearly normal (mild dysphonia); 3-moderate dysphonia; 4-severe dysphonia; 5-aphonia.

Trial of decannulation: If the glottic aperture was clinically found to be adequate, and the pulmonary function tests revealed improvement in PIFR and $FIF_{50,}$ the tracheostomy tube of the patients was corked and kept under observation for 24 hours. If the patient was comfortable he was decannulated.

Results

The study included 17 patients of bilateral vocal cord immobility. There were 10 males (58.7%) and 7 females (41.3%).

The age of the patients ranged from 4 years to 69 years. The mean age of the patients was 37.2 years with a standard deviation of 22.1. Two out of the 17 patients were children less than 12 years of age.

The most common etiological factor was iatrogenic, i.e a result of previous thyroid surgery (7 patients). In others, the etiology was secondary to thyroid malignancy, external trauma, cricoarytenoid fixation due to rheumatoid arthritis, and hypokalemic periodic paralysis in 1 patient each. In 6 patients, the cause of the paralysis could not be determined after appropriate radiological investigations and endoscopic evaluation of the nasopharynx, larynx and hypopharynx and was hence termed idiopathic.

Sixteen out of the 17 patients presented to us, with a pre-existing tracheostomy. Three patients had previously undergone corrective surgical procedures with failure to achieve decannulation. 2 patients had undergone external arytenoidectomy, and 1 had undergone the suture lateralization procedure.

Pulmonary function tests were done on 15 of these 17 patients preoperatively. Two patients were less than 12 years of age and since the machine was not calibrated for these patients, the tests could not be done on them (patient 6 and patient 17). One patient (patient 8) had very low values which could not be picked up by the spirometer and hence a value of 0 was obtained. A flow volume loop was obtained for the remaining patients. The PIFR ranged from 0 to 1.57 l/sec, with a mean of 1.029 l/sec.

The FIF_{50} ranged from 0 to 1.2 l/sec with a mean of 0.84 l/sec (Table 1).

The primary corrective surgical procedures performed on these patients included 9 laser posterior cordectomy with partial arytenoidectomy, 5 endoscopic arytenoidectomy and 3 radiofrequency posterior cordectomy. The surgeries were performed by four different surgeons.

Two patients who had undergone endoscopic arytenoidectomy developed symptoms of mild aspiration in the postoperative period. These patients needed Ryle's tube feeding for 1 week after which the symptoms resolved.

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The success of the surgical procedure was defined in terms of decannulation of the patients. Twelve out of 17 patients were successfully decannulated, a success rate of 70.6% (Fig. 1).

The decannulation rate for individual surgeries was determined: the operation specific decannulation rate (OSDR). Six out of the 9 patients who underwent Laser posterior cordectomy with partial arytenoidectomy were successfully decannulated, OSDR of 66.7%. Four out of 5 patients who underwent endoscopic arytenoidectomy were similarly successfully decannulated, OSDR of 80%. Two out of 3 patients who underwent radiofrequency posterior cordectomy were successfully decannulated, OSDR of 66.7%.

Postoperatively pulmonary function tests were done on 15 patients, just prior to attempted decannulation. The

Table 1 Change in inspiratory flow rates following surgery

S. No.	FIF50 (l/sec) {pre-op}	FIF50 (l/sec) {post-op}	FIF50 (Increase)	PIFR (l/sec) {pre-op}	PIFR (l/sec) {post-op}	PIFR (Increase)
1	1.2	1.85	0.65	1.57	2.03	0.46
2	0.65	0.81	0.16	0.80	0.94	0.14
3	0.76	1.82	1.06	0.93	1.95	1.02
4	0.74	1.04	0.3	0.81	1.25	0.44
5	0.9	1.83	0.93	1.47	1.92	0.45
6	*	*	*	*	*	*
7	1.17	1.27	0.1	1.19	1.27	0.08
8	0	0.88	0.88	0	0.93	0.93
9	0.48	0.86	0.38	0.68	0.93	0.25
10	0.75	1.05	0.3	1.31	1.64	0.34
11	1.21	1.45	0.24	1.36	1.54	0.18
12	0.62	0.71	0.09	0.69	0.95	0.26
13	1.1	1.48	0.37	1.18	1.5	0.32
14	1	0.38		1.12	0.59	
15	0.82	0.92	0.1	1.01	1.2	0.19
16	1.01	1.42	0.41	1.08	1.49	0.41
17	*	*	*	*	*	*
Mean	0.84	1.20	0.44	1.029	1.34	0.41

* Flow volume loop not obtained (<12 years)

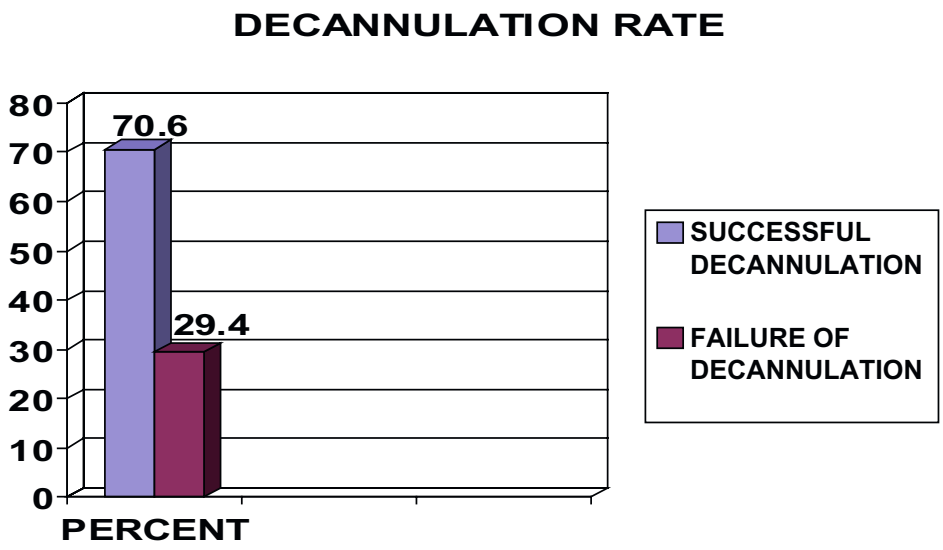

Fig. 1 Decannulation rate

postoperative PIF ranged from 0.59 l/sec to 2.03 l/sec with a mean of 1.34 l/sec. The FIF_{50} ranged from 0.38 l/sec to 1.85 l/sec with a mean of 1.20 l/sec. Except one patient, all the patients showed an increase in mid inspiratory flow rates and peak inspiratory flow rates. The mean increase in FIF_{50} was 0.44 (52.6%) and the mean increase in PIFR was 0.41 (39.77%).

The voice was subjectively analysed by a speech pathologist using Koufmans grading scale

Postoperatively, 8 patients had mild dysphonia (grade 2), 7 had moderate dysphonia (grade 3) and 2 had severe dysphonia. The voice worsened on Koufmanns grading scale in 3 out of the 17 patients (18.2%), by 1 grade.

Out of the 12 patients who were successfully decannulated, 10 patients could carry out the same level of physical activity as they used to with a tracheostomy. However in 2 patients, decannulation entailed a decrease in the level of physical activity leading to a sedentary lifestyle, but complained of mild respiratory distress on climbing stairs or in the presence of an upper respiratory tract infection.

The follow-up period of these patients ranged from 6 months to 30 months with a mean of 11.06 months

Non-parametric tests were applied for all statistical analysis because of a small sample size

The increase in PIFR and FIF_{50} were analysed using Wilcoxon Signed Ranks test. A significant increase in PIFR and FIF_{50} following surgery was found as indicated by a P value of 0.011and 0.08 respectively.

When the increase in FIF_{50} and PIFR following the three surgical procedures performed in the study were compared, no statistically significant difference in improvement of inspiratory flow rates was observed.

Discussion

Three surgical procedures on the 17 patients were used in the present study to evaluate and compare the results in terms of airway restoration and voice preservation.

The parameters used to assess the airway (PIFR and FIF_{50}), showed an increase following surgery, with the mean increase in PIFR of 0.41 l/sec and FIF_{50} of 0.44 l/sec.

We tried to derive a critical threshold of these flow rates as a parameter for decannulation. Kashima et al. (1991) [8] used the same parameters for assessment of results and noted that the mean FIF_{50} improved from 0.89 l/sec to 1.6 l/sec and PIFR improved from 1.32 l/sec to 2.35 l/sec. On the basis of their clinical observations, they regarded a FIF_{50} of 1.5 l/sec or more to be the critical threshold for re-establishing a safe and effective airway.

Zealer et al. (2002) [2] in his analysis of patients with electrically stimulated glottic opening observed that PIFR was the most critical measure in assessing the airway in bilateral abductor paralysis. According to this study, PIFR varied inversely with the level of airway resistance during inspiration and reflected the adequacy of the upper airway. They observed that a PIFR of 1.5 l/sec was sufficient for an adult to undergo decannulation and lead an active ambulant life. The normal PIFR ranged from 2.5–4.5 l/sec and varied according to gender, body, sex and age. However in their study, they did consider a patient of a PIFR of 0.92 l/sec a success, based on the fact that her airflow through the mouth was better than that through her tracheostoma, indicating that a value of 1.5 l/sec was not an absolute requirement for decannulation.

In our study, we observed that the adult males leading an active lifestyle who were decannulated had a PIFR of >1.49 l/sec. However we also observed that it was not possible to fix a specific value of PIFR as a cut-off for decannulation, since the adequate ventilatory function for an individual was also dependent on other factors such as age, sex, the build of the patient in terms of height and weight and the level of activity of the patient. We were able to decannulate 3 patients with a PIFR as low as 0.93–0.95 l/sec, all of whom were females, 45 years of age, and who led an extremely sedentary lifestyle, and were very comfortable following decannulation.Two patients aged 13 years with a PIFR of 0.94 l/sec and 1.25 l/sec were also successfully decannulated. On the contrary, one of the patients who was morbidly obese male, aged 42 years and had an active lifestyle could not be decannulated despite achieving a PIFR of 1.64 l/sec postoperatively, emphasizing the need to take into account patient factors while interpretating pulmonary function tests.

No statistically significant difference in improvement of inspiratory flow rates was observed between the three surgical procedures that were used in the study.

The duration of symptoms, the sex of the patients and the etiology had no significant impact on the decannulation rate as observed by statistical analysis. However, children less than 12 years of age had poor results following surgery, with both the patients in this age group being unable to tolerate decannulation indicating the influence of age in determining results following surgery.

Our success rate of surgey in terms of successful decannulation (70.6%) is slightly lower compared to that reported in literature [3, 8, 10, 11]. However, there was no statistically significant difference among the success rates of the various procedures

The surgical technique of laser posterior cordectomy with partial arytenoidectomy used in present study was the same as that described by Shivero et al. [3].

This we found to be technically the simplest of the various procedures for bilateral vocal cord paralysis; with a reliable outcome and good voice preservation.

The surgical procedure of endoscopic arytenoidectomy used, was a modification of the technique used by Thornell et al. [4]. Until removal of the arytenoid cartilage, the steps used were the same as described by Thornell et al. However, after removal of the arytenoids, the mucosal trapdoor

flap, which had been elevated to expose the arytenoids, was precisely sutured back to ensure that there was no bare area left behind. This prevents the formation of scar shelves and granulations, which could compromise the airway.

This part of the technique has been previously described by Rontal et al. [12]. It was observed that this surgical procedure, although technically demanding, resulted in the best posterior glottic chink; thereby also increasing the risk of temporary aspiration as was seen in two patients. These patients were however easily managed with Ryle's tube feeding for 1 week.

Although the sample size is too small for comparison, this procedure achieved the best results as far as decannulation is concerned (OSDR OF 80%). The present study attempts to illustrate the usefulness of pulmonary function tests in assessing patients with bilateral abductor paralysis and the importance of correlating it with the level of physical activity and emotional profile before considering it as a guideline for decannulation.

References

1. Jackson C (1922) Ventriculocordectomy. A new approach for the treatment of goitrous glottic stenosis. Arch Surg 4: 257–274
2. Zealer DL et al. (2003) Reanimation of the paralyzed human larynx with an implantable electrical stimulation device. Laryngoscope 113:1149–1156
3. Shivero J et al. (2003) Laser posrterior ventriculocordectomy with partial arytenoidectomy for the treatment of bilateral vocal cord immobility. J Laryngol Otol 117: 540–543
4. Thornell WC (1948) Intralaryngeal approach for arytenoidectomy in bilateral abductor paralysis. Arch Otolaryngol 47:505–509
5. Ossof RH et al. (1984) Endoscopic laser arytenoidectomy for the treatment of bilateral vocal cord paralysis. Laryngoscope 94:1293–1297
6. Dennis DP, Kashima H (1989) Carbon dioxide laser posterior cordectomy for the treatment of bilateral vocal cord paralysis. Ann Otol Rhinol Laryngol 98:930–934
7. Hartnick CJ et al. (2003) Surgery for pediatric vocal cord paralysis: a retrospective review. Ann Otol Rhinol Laryngol 112:1–6
8. Kashima HK (1991) Bilateral vocal fold motion impairment: Pathophysiology and management by transverse cordotomy. Ann Otol Rhinol Laryngol 100:717–721
9. Koufman AJ (1984) Laryngoplasty for vocal cord medialization: an alternative to Teflon. Laryngoscope 96: 726–731
10. Whicker JH, Devine KD (1972) Long term results of Thornell arytenoidectomy in the surgical treatment of bilateral vocal cord paralysis. Laryngoscope 82: 1331–1336
11. Ossof RH et al. (1990) Endoscopic laser arytenoidectomy revisited. Ann Otol Rhinol Laryngol 99:764–71
12. Rontal M, Rontal E (1990) Endoscopic laryngeal surgery for bilateral midline vocal cord obstruction. Ann Otol Rhinol Laryngol 99:605–610