The Laryngoscope

A New Solution for Neonatal Bilateral Vocal Cord Paralysis: Endoscopic Arytenoid Abduction Lateropexy

Shahram Madani, MD; Ádám Bach, MD; Vera Matievics, MD; Eszter Erdélyi, MD; Balázs Sztanó, MD, PhD; Ilona Szegesdi, MD; Paul F. Castellanos, MD, FCCP; László Rovó, MD, PhD

Objectives/Hypothesis: Bilateral vocal cord paralysis in early childhood is a life-threatening condition, which often requires immediate intervention. One of the treatment options is a quick, reversible simple suture vocal cord lateralizing technique, whereby the arytenoid cartilage is directly lateralized to the normal abducted position. Considering pediatric laryngeal anatomy, a small endolaryngeal thread guide instrument was designed for precise suture insertion.

Study Design: New instrument validation.

Methods: Four newborns had inspiratory stridor immediately after birth; two had to be intubated. Laryngotracheoscopy revealed bilateral vocal cord paralysis. Unilateral, left-sided endoscopic arytenoid abduction lateropexy was performed with supraglottic jet ventilation on the 4th, 5th, 5th, and 27th day of life for the four patients, respectively.

Results: All babies remained intubated for 3 to 7 days with an uncuffed tracheal tube. After extubation, no dyspnea or swallowing disorder occurred. A subjective quality of life questionnaire, laryngotracheoscopy, clinical growth charts, and voice analysis showed satisfactory functional results.

Conclusions: Minimally invasive, quick, reversible endoscopic arytenoid abduction lateropexy might be a more favorable solution for neonatal bilateral vocal cord paralysis than earlier treatment strategies. In one step, the airway can be maintained without the risk of any permanent damage to voice production. Good swallowing function is also preserved. The specially modified endolaryngeal thread guide instrument gives a fast and effective option for creating the lateralized arytenoid position even in the technically challenging surgical context of a neonate larynx.

Key Words: Bilateral vocal fold paralysis, dyspnea, endolaryngeal thread guide instrument, endoscopic arytenoid abduction lateropexy, laterofixation, neonatal.

Level of Evidence: 4.

***Laryngoscope*, 00:000–000, 2016**

INTRODUCTION

The treatment of bilateral vocal cord paralysis is a challenge in children, especially in neonates. This phenomenon has multiple etiologies. These include iatrogenic, neurological, idiopathic, joint fixation, and birth trauma. Idiopathic paralysis is the most common, but a neurological origin is presumable in those cases as well.[1] According to the literature, two-thirds of paralytic patients have shown some or even total recovery.[2–4] Thus, due to the heterogeneity of the pathology, each case needs to be assessed on its own merit as to whether long-term improvement is possible. Associated stridor and respiratory distress, however, generally require urgent interventions because the "watch and wait" policy may lead to a dire outcome, considering the tiny airways of babies.[5] The possible treatment options in neonates are much more limited compared those in adulthood. This is because achievable airway improvement with classic resection procedures (such as partial/total arytenoidectomy or transverse cordotomy) is limited by the associated edema, which often makes a tracheostomy necessary.[6] Despite the high spontaneous recovery rate after a short period of oxygen hood therapy or intubation, in most cases, tracheostomy is the conventional treatment strategy, with its well-known challenging care problems, as well as psychological and physical side effects.[4,7,8]

Our recent publication objectively proved, in accordance with the clinical observations, that of the popular glottis-enlarging surgeries, those procedures that are based on the natural abduction of the cricoarytenoid joint(s) are the most effective in airway improvement.[9–12] Moreover, these "simple suture procedures" are reversible, which makes the abovementioned decision making easier. The problems that arise with these arytenoid lateropexies in this age group are obvious; the small anatomical structures and the relatively long and difficult surgical procedures practically exclude the application of the external approaches. The faster and simpler endoscopic procedure described by our team is

From the Department of Otorhinolaryngology and Head and Neck Surgery, Stepping Hill Hospital, Stockport National Health Service Foundation Trust, Stockport, United Kingdom (S.M.); Department of Otorhinolaryngology and Head and Neck Surgery, Faculty of Medicine, University of Szeged, Szeged, Hungary (A.B., V.M., E.E., B.S., L.R.); Department of Anesthesiology and Intensive Therapy, Faculty of Medicine, University of Szeged, Szeged, Hungary (I.S.); and Department of Otolaryngology–Head and Neck Surgery, University of Alabama at Birmingham, Birmingham, Alabama, U.S.A. (P.F.C.).

Editor's Note: This Manuscript was accepted for publication September 12, 2016.

The authors have no funding, financial relationships, or conflicts of interest to disclose.

Send correspondence to Ádám Bach, 111. Tisza Lajos krt., 6725, Szeged, Hungary. E-mail: bach.adam@med.u-szeged.hu

DOI: 10.1002/lary.26366

TABLE I.
Pregnancy Information and Patient Data.

Patient/Sex	Gestational Age, wk	Delivery	Apgar Score	Birth Weight, g/Weight-for-Age Percentile	Stridor/ Cyanosis	QOL	Intubation, Days After Birth	Comorbidity
#1/M	39	SVD	9-7-7	3,370/61.7	Y/Y	25	1	–
#2/F	39	Caesarean section (transverse lie)	7-10-10	3,600/78.1	Y/N	25	4	Cavum septum pellucidum cyst, perinatal infection
#3/F	36	SVD	8-7-7	2,210/0.6	Y/N	15	N	Prematurity, perinatal infection, neonatal hypoglycemia
#4/M	39	Caesarean section (weak contractions)	7-10-10	3,250/51.5	Y/Y	16	N	Congenital suprabulbar paresis, relative stenosis of the left bronchus

F = female; M = male; N = no; QOL = quality of life score; SVD = spontaneous vaginal delivery; Y = yes.

also challenging, considering that the endolaryngeal thread guide instrument (ETGI; Mega Kft, Szeged, Hungary) was designed for adults and not such a small glottic area. To alleviate this problem, a prototype of a new commutable blade and stem-pipe was designed so that the original instrument could be used in the neonatal airway.

MATERIALS AND METHODS

Patients

Four newborns with congenital bilateral vocal cord paralysis (BVCP) were chosen as patients. All had been admitted to the perinatal intensive care unit (PICU) immediately after birth due to severe stridor and inspiratory dyspnea. Pregnancy information and patient data are reported in Table I. The complex preoperative examination process included neonatological, neurological, and otolaryngological investigations.

Modification of the Original ETGI

Endoscopic arytenoid abduction lateropexy (EAAL) has already been shown to be safe and effective for the treatment of vocal cord immobility of various etiologies.[9,10,13] However, the small glottic area of newborns made the use of the original the ETGI difficult, so it had to be modified.[14] First was the miniaturization of the instrument to make it easier to maneuver in the neonatal glottis. The small glottic size and the thin soft tissue layer over the larynx require a shorter and less curved endolaryngeal portion of the pipe-stem compared to the curve of the adult-sized device, depicted in Figure 1. Second was the conversion to the neonatal Miller laryngoscope (size 0; Welch Allyn, Skaneateles Falls, NY), which provides a good view for the lateralization of the left arytenoid cartilage (in three cases). In the last patient, a Macintosh Baby Laryngoscope (Welch Allyn) was used to expose the larynx.

Surgical Technique

Unilateral, left-sided EAAL was performed in four neonates on the 4th, 5th, 5th, and 27th day of life, respectively. All operations were performed under general anesthesia via total intravenous anesthesia and high-frequency supraglottic jet ventilation with continuous, strict monitoring of saturation and end-tidal CO_2 and readiness for possible intubation. Jet ventilation was performed by using the Acutronic Ams 1000 device

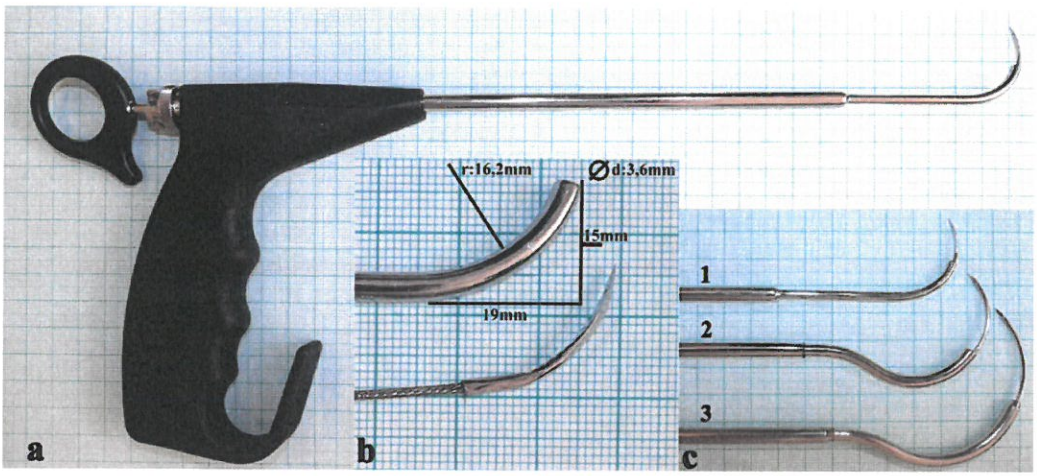

Fig. 1. Endolaryngeal thread guide instrument. (a) Handling, stem-pipe, and curved blade in pushed-out position (stem-pipe and blade designed for infants). (b) Stem-pipe and blade designed for infants. d = external diameter; r = radius of curvature. (c) 1) Stem-pipe and blade designed for infants, 2) stem-pipe and blade designed for women, and 3) stem-pipe and blade designed for men. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

TABLE II.
Details of the Surgery and Events of the Postoperative Care.

Patient/ Sex	EAAL, Days After Birth	Endolaryngeal Surgical Time, min	Postoperative Complication	Extubation, Postoperative Day	Reintubation, Postoperative Day	Oral Feeding, Postoperative Day
#1/M	4th	6	N	5th	N	7th
#2/F	5th	5	Laryngeal edema	7th	26th–32th	10th
#3/F	5th	8	N	3th	N	4th
#4/M	27th	6	N	7th	N	9th

EAAL = endoscopic arytenoid abduction lateropexy; F = female; M = male; N = none.

(Acutronic Medical Systems, Hirzel, Switzerland) with the following parameters: inhalation time = 40% to 50%, frequency = 50 to 60/min, volume = 200 to 300 mL, respiratory minute volume = 1.2 to 1.5 L; pressure = 50 mbar. The procedure began with direct endoscopic examination of the upper and lower airways to the level of the distal trachea with a rigid 0° and 30° endoscope. Performance of the EAAL followed immediately afterward during the same session.

Apart from the size and structural changes of the ETGI, the lateralization of the arytenoid cartilage was performed as described in our earlier publication.[9] After disinfection of the laryngeal mucosa, the ETGI is led through the laryngoscope to the glottic level. The mobile arytenoid cartilage is tilted backward and upward with the end of the instrument. The built-in, curved blade is then pushed through, under the vocal process, and out to the surface of the neck. A nonabsorbable suture thread (0-Prolene; Ethicon, Somerville, NJ) is laced through the hole at the tip of the blade by an assistant surgeon. The doubled-over thread is pulled back with the blade, into the laryngeal cavity. After a repeated tilting of the arytenoid cartilage, the blade is pushed out with the thread above the vocal process to the outer surface of the neck. The assistant surgeon then cuts the double-folded thread to remove it from the blade tip. The blade is then pulled back into the laryngeal cavity, and the ETGI can be removed. A small skin incision is then created to withdraw the ends of the thread by a Jansen hook to the surface of the sternohyoid muscle. The corresponding ends are knotted above it.[9]

The total and the endolaryngeal operation time (from the introduction of the ETGI until its final removal) was noted. At the end of the surgery, the babies remained intubated for 3 to 7 days with an uncuffed tracheal tube (patients 1, 2, 4: inner diameter [ID] = 3.5 mm; patient 3: ID = 3 mm; Portex siliconized polyvinyl chloride oral/nasal uncuffed tracheal tube; Smiths Medical, Plymouth, MN). The size of the endotracheal tube was chosen by age- and weight-based formula according to the advice of the anesthesiologist.[15]

Parenteral antibiotic (amoxicillin/clavulanic acid, 25 mg/5 mg/kg for 12 hours) was administered for 4 days, and methylprednisolone (4 mg/kg) was administered for 7 days. On the day of extubation, the patients were given a steroid bolus. Nasogastric feeding was used for all patients while they were intubated. The postoperative management took place in the PICU in each case.

Follow-up

The functional outcomes of the surgery in terms of breathing, voice, swallowing, and overall satisfaction were evaluated by the quality of life (QOL) questionnaire of the Lausanne team.[16] Follow-up evaluations included regular endoscopic examinations under general anesthesia using a rigid 0° and 30° endoscope. The grade of the vocal cord movement recovery was noted. Body weight gain, length growth, and swallowing difficulty were systematically registered by the parents.[17] The voice samples were recorded with a high-sensitivity (40Hz–16kHz) condenser head microphone (ATM75; Audio-Technica, Machida, Tokyo, Japan) at a sampling frequency of 96 kHz (24-bit US-122MkII external soundcard; TASCAM, Montebello, CA), and analyzed by Praat 5.3.2.9. software (www.praat.org). The following acoustic parameters were recorded in this study: mean pitch, jitter, shimmer, and harmonics-to-noise ratio. Follow-up intervals were 17, 11, 13, and 55 months for the four patients, respectively.

RESULTS

The mean total surgical time was 17 minutes, with an average of 6 minutes spent on the endolaryngeal lateralization. No major perioperative or postoperative complications occurred. The postoperative timeline of events is presented in Table II. Extubation was considered safe on the 5th, 7th, 3th, and 7th postoperative day in the four patients, respectively. In the case of infant #2, extubation was attempted on the 4th postoperative day, but due to significant edema of the laryngeal mucosa, the intubation had to be prolonged by 3 days. Dyspnea and CO_2 retention were noted on the 26th postoperative day. Direct endoscopic examination revealed severe edema of the glottic soft tissues. Thus, reintubation and repeated antibiotics were required for another 6 days. All patients were able to tolerate a normal per os diet with no restriction in 1 to 3 days postextubation. The weight-for-age and length-for-age percentiles are depicted in Figure 2. The acoustic parameters, QOL scores, and characterization of vocal cord movement recovery are shown in Table III. Compared to the preoperative values, the QOL scores improved significantly in all cases. Based on the parent's observations, the voice of the patients was normal in three cases and slightly impaired in one case. In the first three patients, the crying sounds were powerful. Gurgling and cooing were similar to their siblings, according to the parents. Speech development was appropriate in the fourth case, which was the only case followed long enough (55 months) to be evaluated adequately. Partial regeneration of vocal cord movements was observed in two of the four cases: bilateral in infant #2 and unilateral in #3, at 6 and 3 weeks of age, respectively (Fig. 3). Lateralization sutures were not removed in any of the cases.

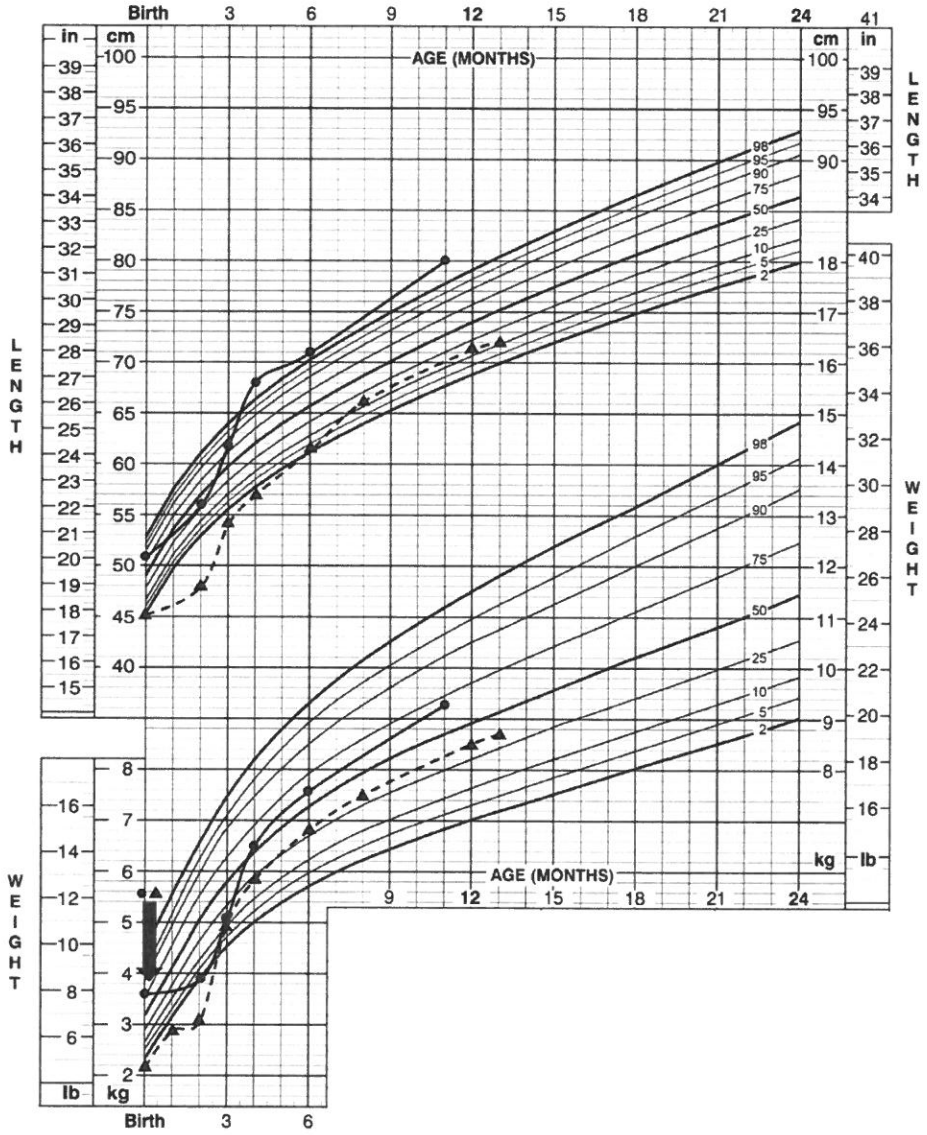

Fig. 2. Length-for-age and weight-for-age percentiles of the patients. (a) Length-for-age and weight-for-age percentiles of patients #2 and #3. Dots indicate patient #2; triangles indicate patient #3; arrow indicates day of surgery. (b) Length-for-age and weight-for-age percentiles of patients #1 and #4. Dots indicate patient #1; triangles indicate patient #4; arrows indicate day of surgery.

DISCUSSION

Due to the many etiologies of BVCP, the potential comorbidities, the related anatomical abnormalities, and the complex requirements of the treatment, many authors recommend a "watch and wait policy" in neonates.[5] However, the associated airway limitations significantly limit the normal physical activity and development of the child, even in milder cases.[2] In cases of severe dyspnea, tracheotomy is still the most frequently performed surgical intervention despite its many well-known risks, including severe complications such as airway stenosis and accidental decannulation, which can be life threatening.[4,7,8,18] The need to minimize surgery in the neonate and the many risks of neonatal anesthesia (small reserve capacity, high oxygen requirements, risk of hypothermia and hyperthermia, undiagnosed heart problems, limited cardiac output, etc.) make surgical options even more limited in this age group. The optimal surgical intervention would be both quick and reversible as well as provide an immediate adequate airway, acceptable voice quality, and good swallowing function. A simple suture lateralization technique of the vocal cord from an external approach was introduced by Zawadzka-Głos in children aged 1 year and older,[19] but this technique did not become popular. Triglia et al. applied arytenoid lateropexy from an external approach on 15 children between 1 month and 9 years old with more encouraging results; however, the undertaking of this relatively complex and long-lasting intervention is significant in neonates. Because of the

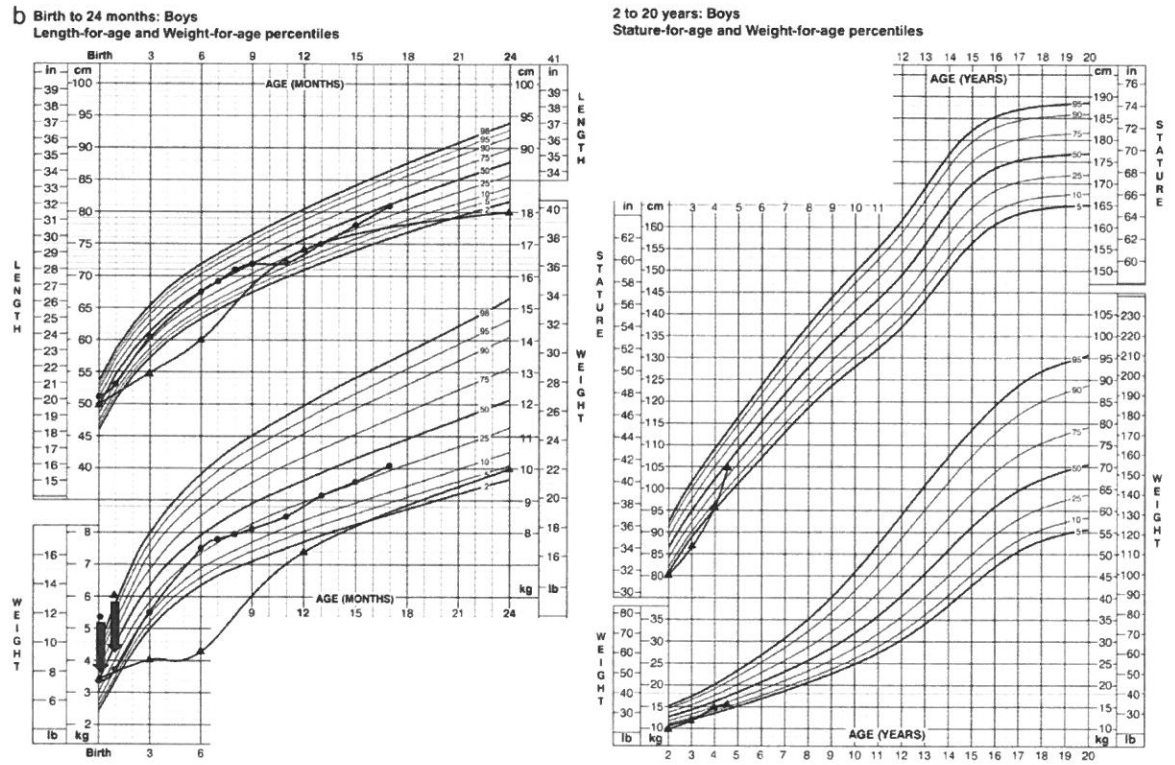

Fig. 2. (Continued)

extensive, surgical dissection of the arytenoid region and the resulting scar formation, this procedure is considered to be irreversible even on adults.[20–23]

Our preliminary results show that EAAL can be relatively easily and quickly performed with low surgical stress even in the first days of life. Moreover, it provides a stable, long-lasting, and wide airway that is potentially reversible because the endoscopically inserted lateralization sutures do not significantly disturb the anatomical structures. This has been proven in several adult cases in which definite reinnervation occurred.[9,10,12,15,24]

The supraglottic jet ventilation and the novel use of pediatric laryngoscopes ensure excellent visualization of the glottis with access unencumbered by an endotracheal tube. If jet ventilation is not available, however, this fast procedure can be performed under spontaneous ventilation with intermittent intubation.[9] Based on our experience, the new, modified ETGI is suitable for fast and safe maneuvering in the narrow laryngeal space of newborns. The blade is connected with the stem-pipe continuously; thus, the device can be removed promptly in case of the need for intubation (Fig. 1). Visual control during the technique is paramount. Moreover, the positioning of the lateralization suture can be made more precisely with endoscopic guidance. With these associated technologies and instrumentation, the procedure can be performed quickly and safely. This intrinsically reduces the potential complications from anesthesia and jet ventilation. In adult patients, no postoperative intubation, temporary tracheostomy, or intensive care are required after EAAL. Due to the limited anatomical space,

TABLE III.
Functional Outcomes of the Surgery.

Patient	Jitter, %	Shimmer, %	HNR, dB	Mean Pitch, Hz	QOL	Vocal Cord Movements	Follow-up, mo
#1/M	0.3	5.4	15.9	171.7	11	N	17
#2/F	5.9	20.1	3.5	261.1	8	R: complete abduction and adduction L: slight adduction	11
#3/F	0.4	4.6	16.4	360.4	7	R: complete abduction and adduction	13
#4/M	1.3	4.7	18.5	328.0	6	N	55

F = female; HNR = harmonic-to-noise ratio; L = left side, M = male; N = no movement; QOL = quality of life score; R = right side.

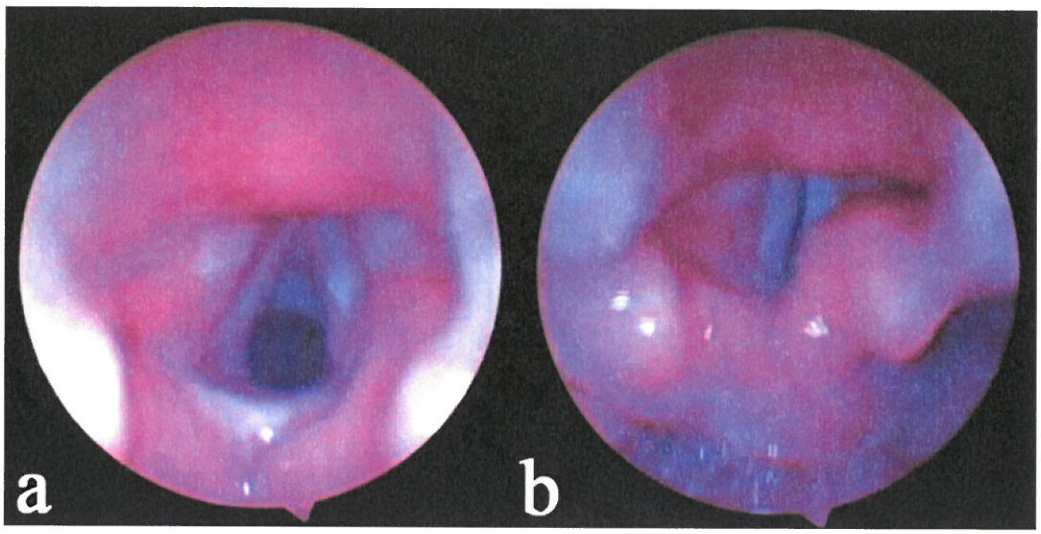

Fig. 3. Complete regeneration of the right vocal cord movements after left-sided endoscopic arytenoid abduction lateropexy (patient #3, 3rd postoperative week). (a) Right side abduction. (b) Right side adduction.

increased vulnerability, and swelling of the soft tissue of the neonates, a short-term postoperative intubation is always prudent along with parenteral steroid therapy. Temporary intubation may also help by the maintaining the lateralized position of the arytenoid cartilage, although our report did not compare this to any cases that were immediately extubated. Perioperative empiric intravenous antibiotic therapy is also indicated.

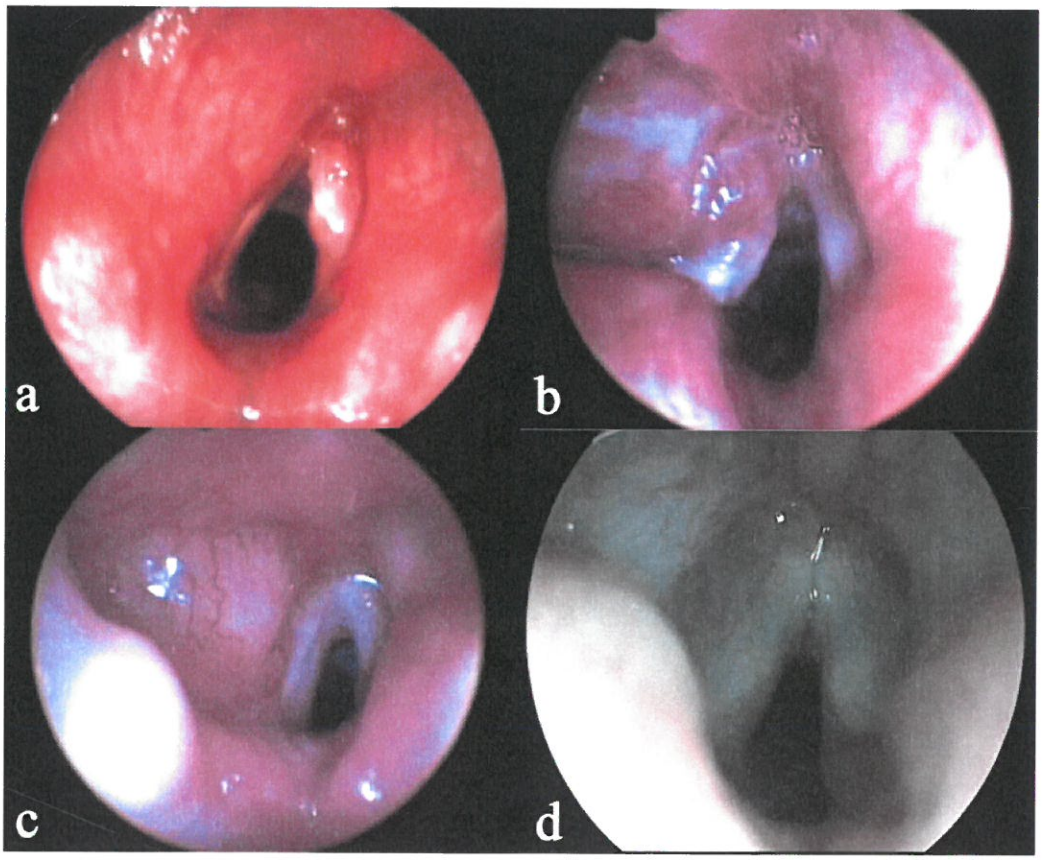

Fig. 4. Endoscopic pictures of the lateralized left vocal cord. (a) Patient #1 (3rd postoperative week). (b) Patient #2 (2nd postoperative week). (c) Patient #3 (2nd postoperative month). (d) Patient #4 (4th postoperative year).

The presented lateralization technique does not impair laryngeal sensation, which is essential for protective laryngeal reflexes.[25] This is consistent with our experience in adult patients who have not had significant aspiration after arytenoid cartilage lateralization. After the removal of the nasogastric feeding tube, the newborns in this series could be easily fed and nurtured. This is supported by parental reports and by the registered weight gain and length growth. Despite the comorbidities and the long hospitalizations, the weight-for-age and length-for-age percentiles show a normalization after the initial growth delay. The objective measurements of voice quality are very limited at this age, but the results of the voice analysis are consistent with the QOL questionnaire's results. The postoperative glottic configuration of a small angle in the anterior commissure and the straight and tensed vocal cords allows acceptable phonation closure in case of contralateral vocal cord recovery.[10,26] This not only allows voice improvement after spontaneous reinnervation, as was seen in the second and third case, but helps to maintain the airway patency. This procedure is reversible in adults, and therefore likely reversible in children. However, we did not undertake any reversal on the infants during this study period. Reversal needs to be carefully considered, because reinnervation of the two vocal cords does not necessarily occur simultaneously. We have observed in adults that when reversal is undertaken because the contralateral vocal cord's movement has recovered, the released (but potentially still paralyzed) vocal cord can remedialize after the suture removal.[27] Although that is acceptable in an adult, in the young and very small larynx this medialization might cause a significant increase in airway resistance. As the unilateral lateralization suture does not cause any swallowing or phonation impairment, it was not removed after partial functional recovery. This was in accord with the parents' decision. The suture removal can be considered in the future if endoscopic and/or laryngeal electromyographic examinations confirm the reinnervations or when the larynx has grown larger.

Endoscopic examinations proved the stable position of the lateralization sutures and the abducted arytenoid cartilage after 4 years in the one patient we followed for that long. This surgical intervention might be a long-term solution, even in fast-growing laryngeal structures (Fig. 4).

CONCLUSION

According to our preliminary results, the minimally invasive and quick EAAL might be a more favorable solution for neonatal BVCP than earlier treatment strategies. In one step, the airway can be maintained without the risk of any permanent damage to voice production. Good swallowing function is also preserved. In addition to these benefits, it should be easily reversible. The specially modified ETGI gives a fast and effective option to create the lateralized arytenoid position even in the technically challenging surgical context of a neonatal larynx. Follow-up long-term outcomes and additional patients need to be studied to further validate this procedure.

Acknowledgment

The authors thank Dr. Kathleen I. Castellanos for reviewing the manuscript.

BIBLIOGRAPHY

1. Benjamin JR, Goldberg RN, Malcolm WF. Neonatal vocal cord paralysis. *Neo Rev* 2009;10;494–501.
2. Takamatsu I. Bilateral vocal cord paralysis in children. *Nihon Jibiinkoka Gakkai Kaiho* 1996;99:91–102.
3. Gentile RD, Miller RH, Woodson GE. Vocal cord paralysis in children 1 year of age and younger. *Ann Otol Rhinol Laryngol* 1986;95:622–625.
4. Jomah M, Jeffery C, Campbell S, Krajacic A, El-Hakim H. Spontaneous recovery of bilateral congenital idiopathic laryngeal paralysis: systematic non-meta-analytical review. *Int J Pediatr Otorhinolaryngol* 2015;79: 202–209.
5. Chen EY, Inglis AF Jr. Bilateral vocal cord paralysis in children. *Otolaryngol Clin North Am* 2008;41:889–901.
6. Aubry K, Leboulanger N, Harris R, Genty E, Denoyelle F, Garabedian EN. Laser arytenoidectomy in the management of bilateral vocal cord paralysis in children. *Int J Pediatr Otorhinolaryngol* 2010;74:451–455.
7. Miyamoto RC, Parikh SR, Gellad W, Licameli GR. Bilateral congenital vocal cord paralysis: a 16-year institutional review. *Otolaryngol Head Neck Surg* 2005;133:241–245.
8. Lesnik M, Thierry B, Blanchard M, et al. Idiopathic bilateral vocal cord paralysis in infants: case series and literature review. *Laryngoscope* 2015;125:1724–1728.
9. Rovo L, Madani S, Sztano B, et al. A new thread guide instrument for endoscopic arytenoid lateropexy. *Laryngoscope* 2010;120:2002–2007.
10. Szakacs L, Sztano B, Matievics V, et al. A comparison between transoral glottis-widening techniques for bilateral vocal fold immobility. *Laryngoscope* 2015;125:2522–2529.
11. Woodson G. Arytenoid abduction for bilateral vocal fold immobility. *Curr Opin Otolaryngol Head Neck Surg* 2011;19:428–433.
12. Sandhu GS, Nouraei SAR, Rovo L, Marie JP, Mueller AH, Castellanos PF. Bilateral impaired vocal cord mobility. In: Sandhu GS, Nouraei SAR, eds. Laryngeal and Tracheobronchial Stenosis. San Diego, CA: Plural Publishing; 2016:195–227.
13. Rovo L, Venczel K, Torkos A, Majoros V, Sztano B, Jori J. Endoscopic arytenoid lateropexy for isolated posterior glottic stenosis. *Laryngoscope* 2008;118:1550–1555.
14. A New Endolaryngeal Thread Guide Instrument (ETGI) for Arytenoid Lateropexy. Mega Kft, Szeged, Hungary. Available at: http://www.etgi.info/. Accessed October 10, 2016.
15. Ranu J. Pediatric airway management. In Carin AH, Carlos AA, William H, eds. The Difficult Airway: A Practical Guide. New York, NY: Oxford University Press; 2013:155–164.
16. Jaquet Y, Lang F, Pilloud R, Savary M, Monnier P. Partial cricotracheal resection for pediatric subglottic stenosis: long-term outcome in 57 patients. *Thorac Cardiovasc Surg* 2005;130:726–732.
17. World Health Organization. The WHO child growth standards. Available at: http://who.int/childgrowth/en/. Accessed May 23, 2016.
18. White AC, Purcell E, Urguhart MB, Joseph B, O'Connor HH. Accidental decannulation following placement of a tracheostomy tube. *Respir Care* 2012;57:2019–2025.
19. Zawadzka-Glos L. Surgical treatment of bilateral vocal cord paralysis in children. *N Med* 2008;3:70–72.
20. Schobel H. Dilatation of the glottis in bilateral vocal cord paralysis. Review of various surgical procedures and a report of personal experience using a functional lateral fixation surgical technique [in German]. *HNO* 1986;34:485–495.
21. Woodson G. Arytenoid abduction for bilateral vocal cord paralysis. *Otolaryngol Head Neck Surg* 2012;23:178–182.
22. Brigger MT, Hartnick CJ. Surgery for pediatric vocal cord paralysis: a meta-analysis. *Otolaryngol Head Neck Surg* 2002;126:349–355.
23. Triglia JM, Belus JF, Nicollas R. Arytenoidopexy for bilateral vocal fold paralysis in young children. *J Laryngol Otol* 1996;110:1027–1030.
24. Lichtenberger G. Reversible lateralization of the paralyzed vocal cord without tracheostomy. *Ann Otol Rhinol Laryngol* 2002;111:21–26.
25. Crumley RL. Endoscopic laser medial arytenoidectomy for airway management in bilateral laryngeal paralysis. *Ann Otol Rhinol Laryngol* 1993; 102:81–84.
26. Woodson GE. Spontaneous laryngeal reinnervation after recurrent laryngeal or vagus nerve injury. *Ann Otol Rhinol Laryngol* 2007;116:57–65.
27. Rovo L, Jori J, Brzozka M, Czigner J. Airway complication after thyroid surgery: minimally invasive management of bilateral recurrent nerve injury. *Laryngoscope* 2000;110:140–144.