Chapter 16
Vocal Fold Paralysis and Dysphagia: Challenges and Controversies

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Introduction

The term vocal fold paralysis (VFP) has a spectrum of entities within literature that describe vocal fold motion impairment, including vocal fold immobility, adductor or abductor paralysis, and vocal fold paresis [1]. VFP is known to be a major cause of voice impairment, dysphagia, and respiratory problems. The degree by which these are manifested often depends on whether the patient has unilateral VFP or bilateral VFP, as well as etiology of the VFP, patient age, and other patient characteristics. While the majority of pediatric studies that have focused on the management of VFP have emphasized respiratory and voice outcomes, dysphagia and impaired swallowing function are important consequences of VFP. It is likely that the prevalence numbers for pediatric dysphagia are not accurately represented in the literature and that only a small fraction of the affected children receive services for their swallowing difficulties [2]. This chapter looks to describe the relationship between VFP and dysphagia in the pediatric patient, focusing specifically on the challenges the otolaryngologist faces in the workup and management of this entity.

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Epidemiology

It has been estimated that VFP, both unilateral and bilateral, represents roughly 10% of all congenital laryngeal lesions [3]. Both sexes are equally affected, and these children generally present before 2 years of age. Bilateral VFP has been reported to encompass between 30% and 62% of the VFP cases, [4] although the incidence of unilateral VFP is also increased at pediatric centers with pediatric cardiothoracic surgery. VFP is behind only laryngomalacia as the most common cause of neonatal stridor [5, 6]. With improved technology and advances in practice over the years, VFP is being diagnosed more accurately and frequently. Bilateral VFP patients most commonly present with dyspnea and stridor, and the airway becomes the primary focus of the management of these patients, though they may also have impairments of swallow function and voice. Unilateral VFP children are more likely to present with voice and swallowing problems than dyspnea, but both of these patient groups have additional morbidity due to their aspiration and dysphagia risk, with loss of airway protective mechanisms, including decreased laryngopharyngeal sensation and impaired glottal closure [7].

More than 500,000 children in the United States are diagnosed with dysphagia each year, although this is likely an underestimation of the true burden as parent reporting may not always be accurate, and it has been shown less than 25% of parents seek medical help for this issues [2]. The downstream effects of dysphagia with or without VFP can be significant including the need for gastrostomy tube in some patients. It has been shown the need for gastrostomy tube placement in patients with VFP ranges from 15% to 63% [8–11]. While gastrostomy tubes carry their own risk to the patients, they are also burdensome to the caregivers, as they have been shown to have a much lower quality of life and increased rates of depression [12]. This again highlights one of the many challenges otolaryngologists face when managing pediatric patients with VFP.

Presentation and Workup

Identifying the underlying etiology of VFP is essential and can often dictate the management of the patient. Although children and adults have some overlapping etiologies of VFP, including trauma, neoplasms, or neurologic causes, their frequencies and rates of incidence vary significantly. Previous studies have shown idiopathic causes [13] and iatrogenic trauma from cardiothoracic surgery as two of the most common etiologies of VFP in the pediatric population [11, 14]. The large majority of etiologies for VFP are encompassed by two broad categories: congenital and acquired. Table 16.1 summarizes the etiologies of VFP. The discussion and nuances of each etiology are beyond the scope of this chapter, but specific etiologies will be discussed in further detail later in the chapter in regard to their impact on the management.

Table 16.1 Etiologies of vocal fold paralysis in pediatric population

(I) Acquired
(A) Trauma
(a) Birth injury (e.g., forceps delivery)
(b) Iatrogenic via surgical correction of cardiovascular or esophageal abnormality
(c) Intubation related
(d) Vagal nerve stimulator
(e) Foreign body ingestion
(f) Thyroid surgery
(B) Infections
(a) Guillain-Barré syndrome
(b) Diphtheria
(c) Rabies
(d) Tetanus
(e) Syphilis
(f) Tuberculosis
(g) Botulism
(h) Pertussis encephalitis
(i) Polyneuritis
(j) Polioencephalitis
(C) Neurotoxicity
(a) Vincristine
(II) Inherited
(A) Genetic
(a) Isolated mutation
(b) Autosomal dominant
(c) Autosomal recessive
(d) X-linked
(B) Associated neurologic disease
(a) Charcot-Marie-Tooth disease
(III) Congenital
(A) Peripheral nervous system
(a) Congenital myasthenia gravis
(b) Skull base platybasia
(B) Central nervous system
(a) Meningocele
(b) Meningomyelocele
(c) Arnold-Chiari malformation
(d) Hydrocephalus
(e) Encephalocele
(f) Cerebral agenesis
(g) Nucleus ambiguous dysgenesis

(continued)

Table 16.1 (continued)

(C) Cardiovascular anomalies
(a) Patent ductus arteriosus
(b) Transposition of the great vessels
(c) Vascular ring
(d) Tetralogy of Fallot
(e) Dilated aorta
(f) Double aortic arch
(g) Interventricular septal defect
(D) Associated with other congenital anomalies
(a) Cricopharyngeal stenosis
(b) Esophageal cyst, duplication, atresia
(c) Bronchogenic cyst

Presentation

The signs and symptoms of unilateral or bilateral VFP in a pediatric patient are variable, given the range of effects of an abnormally functioning larynx. Due to their broad presentation of symptoms, the correct diagnosis of VFP is often not made for weeks or months, with symptoms attributed to other respiratory disorders including recurrent croup or asthma [15]. Symptoms of unilateral or bilateral VFP in children include stridor, dysphagia, aspiration, dysphonia, respiratory distress, apnea, ineffective cough, abnormal cry, among others [5, 6, 11]. There are notable differences in presentation between bilateral and unilateral VFP. In bilateral VFP the child's voice or cry is often near normal because his/her vocal folds are typically in a paramedian position. Respiratory symptoms are often much more severe in bilateral VFP cases, including persistent stridor, dyspnea, apneas, or cyanosis [16]. In contrast, unilateral VFP cases are more likely to present with dysphonia, including abnormal cry, breathiness of the voice, or decreased ability to project [16].

Dysphagia is prevalent in both populations of VFP with presenting symptoms including aspiration pneumonia, choking or coughing with feeds, or tachypnea with feeds. The index of suspicion should be high, and threshold for intervention should be low in these children, as a study of children with unilateral VFP suggests that even when aspiration is not seen on modified barium swallow (MBS), children with VFP are still at risk for aspiration pneumonia [14]. There have not been any studies to date that have investigated the discrete differences in dysphagia, aspiration rates, or components of the swallowing mechanisms between unilateral or bilateral VFP.

Workup

Given the wide variety of symptoms with which a child with VFP can present, a thorough history and physical are of utmost importance. During the evaluation of the child, it is important to note presence and degree of stridor, any abnormalities

in their cry or voice, respiratory issues including retractions or tachypnea, and any feeding difficulties. Elicited history should including previous surgeries, particularly cardiac, neck, posterior fossa, or pulmonary surgeries. Other information that should be garnered includes the presence of neurologic disorders, congenital heart disease, congenital anomalies, and, although rare, any history of familial VFP [17].

In cases in which the etiology of the VFP is unclear or unknown, the focus should be on the anatomy of the child, including the brainstem, mediastinum, and vagus nerve (including the recurrent laryngeal nerves) [18]. Dedicated imaging should be performed for these structures, specifically computerized tomography (CT), which is preferred for the neck and chest. Magnetic resonance imaging (MRI) is preferred for the skull base, brain, and brainstem, as it can detect anatomical abnormalities of the brainstem, such as Arnold-Chiari malformation.

The otolaryngologist has a variety of tools at his/her disposal with which to evaluate the larynx and to identify and document VFP, including flexible laryngoscopy, rigid stroboscopy, direct laryngoscopy under general anesthesia, ultrasound, and pulmonary function tests [19–21]. The ideal examination is performed, while the patient is awake to fully assess vocal fold mobility, and flexible laryngoscopy has become the standard procedure for assessment (Fig. 16.1). Despite the advances in technology, evaluation of an infant or small child's larynx may be challenging due to edema, frequent laryngeal movement due to rapid respirations, copious secretions, or concomitant laryngomalacia. Therefore, the addition of the ability to record the examination with playback features that can slow down the video makes flexible laryngoscopy that much more valuable [19].

Laryngeal ultrasound to assess VFP has shown promise in its utility, particularly in low-resource settings where flexible laryngoscopy may not be available. A study comparing diagnosis of VFP with laryngeal ultrasound to direct laryngoscopy with

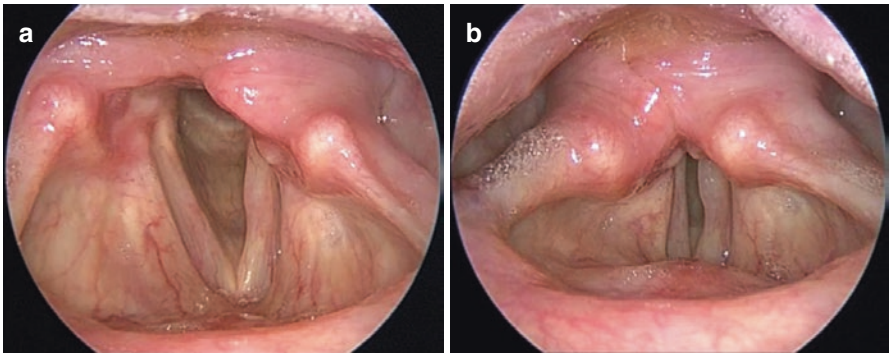

Fig. 16.1 Vocal fold paralysis as seen on flexible fiberoptic nasolaryngoscopy. (**a**) Left vocal fold paralysis results in a shortened and flaccid vocal fold, as compared to the right side during abduction. (**b**) Incomplete glottal closure is seen with adduction, as the left vocal fold remains in the paramedian position. This allows for a gap, resulting in dysphagia and potential aspiration with various consistencies of food/liquid

anesthesia found a concordance rate of 88.2% for unilateral VFP and 82.1% for bilateral VFP [21]. Transcutaneous laryngeal ultrasound can also be used in addition to or in lieu of flexible laryngoscopy to screen for VFP in challenging cases, thus avoiding the hemodynamic changes that may occur in children who do not tolerate flexible laryngoscopy well, as well as potentially avoiding the need for direct laryngoscopy with anesthesia [22]. The relative ease of operating an ultrasound machine and of learning the necessary technique to diagnose VFP makes the ultrasound an attractive option. The laryngeal anatomy of children makes them more ideal candidates for evaluation of VFP with laryngeal ultrasound compared to adults, given their lack of calcification of thyroid cartilage and shorter distance of ultrasound probe to the posterior larynx [22, 23]. Further studies are warranted to confirm its utility.

In certain instances, direct laryngoscopy and bronchoscopy under anesthesia are warranted to fully evaluate a child's larynx and confirm the diagnosis of VFP after noninvasive workup has been completed. Obtaining the appropriate anesthetic plane to evaluate vocal fold motion and the entire airway is of utmost importance with this procedure, so the assistance of a well-trained pediatric anesthesiologist is a necessity. Evaluation in the operating room is also recommended if other airway pathology is suspected, cases involving endolaryngeal trauma or endotracheal intubation, or bilateral VFP. If endolaryngeal trauma or endotracheal intubation is the suspected etiology of VFP, evaluation for cricoarytenoid fixation and posterior glottal stenosis is critical. Operative examination also provides the otolaryngologist with the ability to evaluate the larynx in children with concomitant feeding difficulties. Palpation for a laryngeal cleft, evaluation for tracheoesophageal fistula, or other laryngeal abnormalities is recommended. Assessment of the airway with direct laryngoscopy and bronchoscopy is also indicated in instances where children with suspected VFP cannot be examined at bedside or in the clinic with flexible laryngoscopy due to intolerance of exam, which may be behavioral or physiologic in nature.

Pediatric VFP patients will often have feeding difficulties at the time of diagnosis. While the airway should be the key focus on initial evaluation, dysphagia adds further morbidity to these patients, and swallowing function studies should be considered as an important and crucial component in the evaluation. Both a modified barium swallow (MBS) test and functional endoscopic evaluation of swallow (FEES) are commonly used studies to evaluate swallowing. An MBS can be helpful in characterizing dysphagia, as it can confirm the presence of aspiration, as well as help identify strategies to manage and prevent aspiration (Fig. 16.2). The information gained from an MBS can help determine the need for altering the rate of feeding and texture of feeds to improve the dysphagia or avoid aspiration and its associated complications [14]. Associated mediastinal anomalies, including vascular rings, can also be identified with an MBS. A FEES using the flexible laryngoscope is another option for evaluating swallowing in pediatric patients. Compared to an MBS, a FEES is able to examine swallowing function with multiple food/liquid consistencies, evaluate laryngeal sensation, and has no exposure to radiation. While it cannot distinguish penetration from aspiration due to a white out of

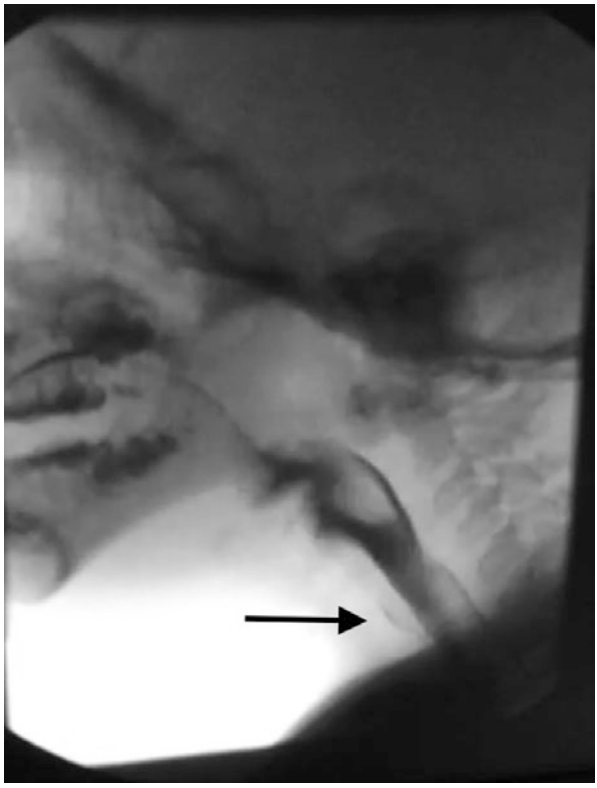

Fig. 16.2 Modified barium swallow demonstrating aspiration into the airway, as noted by the arrow. This can indicate incomplete glottal closure, as can be seen with unilateral vocal fold paralysis

the screen during swallowing, it can give more information regarding the path taken by the food/liquid, thereby giving more detail regarding the etiology of aspiration.

Another confirmatory test for unilateral or bilateral VFP that has been used more frequently in recent years is laryngeal electromyography (EMG). It is especially useful prior to performing a more permanent procedure such as laryngeal reinnervation or thyroplasty, although it does not seem to have much utility in predicting return of function in congenital VFP [24, 25]. In adults, this procedure is often performed in the awake setting, while in children, it typically requires a general anesthetic and is carried out at the time of endoscopy.

Management

Decisions for management strategies are multifactorial in children with VFP. Each case is unique, including their etiology, severity of symptoms, comorbidities, and whether there is unilateral or bilateral involvement. Obtaining and maintaining a safe and stable airway is universally agreed upon as top priority in these patients,

especially if they present in respiratory distress. Other goals in management to be considered include the preservation and possible improvement of speech or voice and improving swallowing function. The management strategy for bilateral vs. unilateral VFP can also differ drastically.

The etiology of the VFP plays a large role in deciding how to manage the patient and especially on timing of interventions. Should the child have a progressive neuromuscular disease process, the spontaneous recovery from paralysis is much less likely than a child that has spontaneous idiopathic unilateral VFP. Children who present with bilateral VFP should be evaluated for a meningomyelocele or Arnold-Chiari malformation before decision is made whether or not to proceed with invasive procedures such as tracheostomy. In these cases, ventriculoperitoneal shunt or posterior fossa decompression procedure should be considered first in order to decrease morbidity and prevent complications [18, 26–28]. Some advocate for securing and supporting the airway for at least 4 weeks prior to tracheostomy, in order to give VFP patients who have a good chance of recovery of vocal fold movement adequate time for recovery prior to moving forward with tracheostomy [18].

There is no established timeframe for laryngeal procedures after diagnosis of VFP, particularly in children with an airway that is stabilized. Decision-making takes into account the child's age and symptoms, as well as the desires and wishes of the parents and the surgeon's experience level and skill [19]. Deciding on the correct time to intervene is also complicated by the fact that recovery of unilateral or bilateral VFP varies within the literature from 16% to 64%, with time to recovery varying from 6 weeks to 11 years [5, 11, 13, 27–30]. The etiology of the VFP also affects the recovery rate, as iatrogenic VFP from cardiothoracic surgery recovers at a rate much lower than idiopathic or congenital VFP [11]. It should be noted while vocal fold movement may recover, it is possible that the child's phonation, respiratory status, or swallowing function may not return to baseline. Laryngeal synkinesis, partial reinnervation, cross-innervation, compensatory mechanisms, or other patient factors may be responsible.

Another important aspect to consider is the urgency with which the procedure is needed based on symptoms. The Food and Drug Administration (FDA) has issued warnings on a number of anesthetic agents for pediatric patients. The associated neurodevelopmental risks have been found to be greater in children less than 3 years of age. Since thickened liquids, nasogastric feeds, and other feeding options can be used to temporize patients until they are at a safer age for intervention under general anesthesia, some have recommended waiting until the child is 3 years of age prior to proceeding with elective surgery [31].

In children who do not spontaneously recover either unilateral or bilateral vocal fold movement, their swallowing function can recover at rates that surpass return of their vocal fold movement [7, 11, 32]. However, children with developmental delay or central neurologic etiology of VFP do not show the same capacity to recover their swallowing function as those children without delay [7, 33]. Patients with multiple deficits in the swallowing mechanisms may have insurmountable obstacles to overcome to safely feed by mouth, regardless of vocal fold motion status [7].

Bilateral Vocal Fold Paralysis

Children with bilateral VFP present more often in respiratory distress than do children with unilateral VFP. The main challenge with these patients is the decision regarding tracheostomy placement. While tracheostomy was previously a common intervention for bilateral VFP, in as many as 67% of cases [28, 34, 35], more recent studies have demonstrated a decrease in the rate of tracheostomy in these patients, to as low as 33% [27, 29, 30, 36]. This is thought to be due to improved neonatal care, the use of positive pressure oxygenation via nasal cannula, and improvement in management and treatment of cardiovascular disorders, among other factors. One of the challenges when deciding whether or not tracheostomy is needed in these patients is deciding how long to wait following diagnosis of vocal fold motion impairment. While the measures described above buy more time prior to having to perform a tracheostomy, there is no consensus on how much time an otolaryngologist should wait prior to placing tracheostomy vs. observation and waiting for recovery. This is in part due to the lack of good evidence in literature and the retrospective nature of most of the case series.

While the decision on the correct time to intervene and place a tracheostomy on a child with bilateral VFP is difficult to determine, it is to be noted that the tracheostomy is a potentially reversible procedure that can allow time for spontaneous recovery of vocal fold movement. It also allows for continual re-evaluation of the vocal folds with flexible laryngoscopy with an unobstructed view of the larynx, while the tracheostomy maintains a stable airway.

Following tracheostomy placement, a further challenge in management arises due to the variable time intervals for potential spontaneous. The otolaryngologist is left to decide how often re-evaluation should take place and how long these children should be followed before further surgical intervention. Neither of these questions have a consensus within the literature. Most physicians advocate waiting several years before more invasive or irreversible procedures (e.g., lateralization, cordotomy, etc.) are performed, with studies demonstrating return of vocal fold movement up to 11 years after diagnosis [13, 28, 30]. In addition, normal laryngeal growth may allow for an increase in glottal aperture, which could decrease the need for any further intervention [30, 37]. Overall, it is shown that roughly 50% of children who have a tracheostomy placed for VFP require the tracheostomy tube to stay in place for greater than 3 years before decannulation is attempted [5, 36].

Once the airway is stable but prior to any irreversible laryngeal procedures in a child with bilateral VFP, dysphagia and the risk of aspiration should be addressed. This is especially true in children with a tracheostomy, as it has the potential to further exacerbate their dysphagia through impaired swallowing function due to decreased hyolaryngeal elevation. Speech therapy should be consulted on any child with bilateral VFP for swallowing evaluation. Studies have shown that roughly 50% of children with bilateral VFP need the assistance of a gastrostomy tube at initial diagnosis [7, 11, 38]. Children with developmental delay and bilateral VFP have been shown to require a gastrostomy tube at a much higher rate than developmen-

tally normal children with bilateral VFP. Furthermore, children with developmental delay are less likely to regain or attain full feeds by mouth even with resolution of their vocal fold immobility [7].

Procedures Beyond Tracheostomy

Laryngeal surgeries and interventions following tracheostomy are most commonly performed to facilitate decannulation. Prior to committing to a surgery to enlarge the patency of the airway, there should be an active discussion with the parents so that they may understand the trade-offs involved, with the potential worsening of swallowing function and sacrifice of voice. This is also the case when performing procedures to widen the glottal aperture in children with bilateral VFP who do not have a tracheostomy. Surgical options fall into two categories: static vs. dynamic. Static procedures are further divided into tissue removal procedures or procedures that modify laryngeal framework. Dynamic procedures involve laryngeal reinnervation or functional electrical stimulation.

Surgeons who perform static procedures can often combine tissue removal techniques and laryngeal framework surgery simultaneously, such as the Woodman procedure or the arytenoid abduction laryngoplasty [39, 40]. Endoscopic techniques that can be used include posterior cordotomy, vocal process resection, arytenoidectomy, or posterior cricoid cartilage split and graft placement [41–43]. Due to the smaller dimensions of the pediatric glottis compared to the adult glottis, postsurgical scar tissue formation can have a large impact, both on the possibility of decannulation and phonation. Scar tissue formation has been noted to cause a higher rate of late failures in children than with adults [44].

The majority of studies involving static procedures have tracheostomy decannulation as the primary outcome. A meta-analysis found that a combination of anterior laryngofissure, arytenoidopexy, and vocal fold suture lateralization was the most reliable procedure to lead to tracheostomy decannulation in pediatric patients with bilateral VFP [4]. There is a paucity of literature that further examines these procedures and their specific effects on voice and/or swallowing in the pediatric population.

While static procedures widen the glottal diameter at the expense of swallowing, the dynamic procedure of selective laryngeal reinnervation by using the ansa cervicalis, phrenic nerve, or branches of the hypoglossal nerve shows some promise for bilateral VFP [45]. If successfully performed, abduction and adduction of the vocal folds may return, which can restore voice and protect airway during swallowing without disrupting the airway [45]. Another dynamic procedure option that can be employed is laryngeal chemodenervation, using injectable material such as botulinum toxin (Botox). Outcomes from a single-institution study demonstrated thyroarytenoid muscle injections to be more effective than cricothyroid muscle injections [46]. It was also more successful in maintaining decannulated status in children with a prior tracheotomy than preventing a tracheotomy in children without one

[46]. Similar to the static procedures, though, the majority of studies for dynamic procedures focus on primary outcome goal of tracheostomy decannulation and little to no focus on voicing and/or swallowing outcomes. Therefore, while success rates of procedures in relation to decannulation are fairly good, there have not been enough studies and adequate evidence to determine the impact of these procedures on dysphagia and dysphonia.

Unilateral Vocal Fold Paralysis

Unlike bilateral VFP, tracheostomy plays a much less prominent role in the treatment and management in children with unilateral VFP, as it usually only necessary if synchronous airway lesions are present [19]. Many of these patients (up to 80%) can be managed conservatively without surgical intervention. This is because the contralateral vocal fold can have effective compensation for glottal closure, which improves swallowing function and potentially dysphonia. Speech therapy can be used to help strengthen these compensatory methods and is often advocated as first line of therapy [18, 19, 47, 48]. The resolution rate of unilateral VFP varies within the literature and is quoted as high as 64%, but is thought to be much lower in iatrogenic cases [11, 29]. For those children who do have resolution of their unilateral VFP, roughly 80% of them will resolve within a year [11].

Surgical intervention is reserved for the 20–40% of patients who remain symptomatic after observation [49]. The challenge lies in deciding the length of the observation period prior to intervention. Most studies suggest waiting at least 1 year prior to intervention. Guiding these management decisions are symptom severity, effect of dysphonia and dysphagia on the child, and knowledge of the natural history of the unilateral VFP [11, 49, 50]. There are three primary surgical interventions that are employed for unilateral VFP: injection laryngoplasty, thyroplasty, and laryngeal reinnervation. There is a scarcity of data on these surgical interventions, and they are guided by level 4 evidence, which is somewhat expected given the low incidence of symptomatic unilateral VFP patients [49].

Injection laryngoplasty is considered a temporary intervention, as the materials used are designed to be eventually reabsorbed by the body (Fig. 16.3). A recent systematic review showed the most commonly used injectable materials include an absorbable gelatin sponge, sodium carboxymethyl cellulose gel, calcium hydroxylapatite, collagen, hyaluronic acid gels, and polytetrafluoroethylene [49]. However, most otolaryngologists who routinely address pediatric unilateral VFP are most likely to use carboxymethyl cellulose gel today, given the short-term nature of the injection material. Calcium hydroxylapatite is typically not used in the pediatric population, given the potential for an intense inflammatory response to the injection material [51]. Two of the studies in the review documented the injectable materials lasting longer in children than would expect in the adult population [49, 52, 53]. As more research is done to evaluate the resultant histologic changes to the tissue following injection, it is possible that further paradigm shifts may be seen in the future.

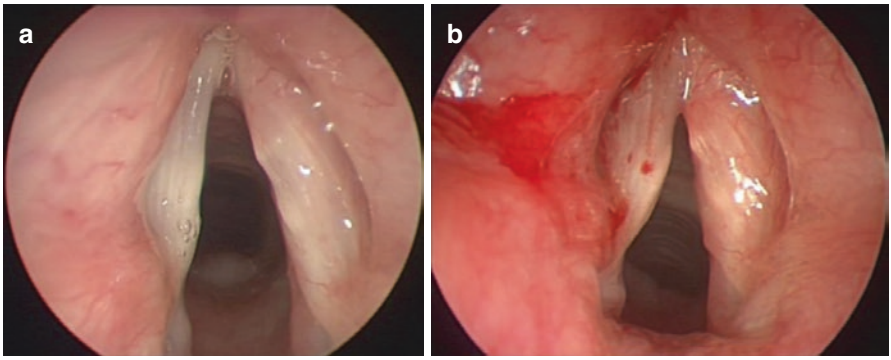

Fig. 16.3 Left injection laryngoplasty as seen on direct laryngoscopy. (**a**) Preinjection. The left vocal fold is paralyzed and demonstrates atrophy. (**b**) Postinjection. The left vocal fold is visibly fuller, with much significant decrease in the distance from the midline and contralateral vocal fold

With regard to outcomes following injection laryngoplasty, the majority of these studies documented that injection laryngoplasty was performed due to dysphonia symptoms with reported rates of objective or subjective improvement of 94–100% [30, 52–56]. These studies also consistently showed improvements in swallowing function on MBS, although the number of patients was limited [30, 52–56]. This surgical intervention is the only procedure for unilateral VFP that is considered temporary, so it is a good option in symptomatic children during the observation period. Recent studies have shown that patients may benefit from early injection as it may reduce the need for a more permanent procedure, such as thyroplasty or recurrent laryngeal nerve reinnervation [57, 58].

Medialization thyroplasty is a more permanent procedure and is commonly performed in the adult population, but is not often implemented in children. The largest case series by Link et al. [59] only involved eight patients treated with type I thyroplasty, most commonly for dysphonia or aspiration symptoms. A systematic review did find a high rate at 88% of aspiration recovery or swallowing function improvement after thyroplasty [49]. There are several reasons why this procedure has not been highly utilized in the pediatric population. First, in adults this is performed under local anesthesia and mild sedation, with the ability to adjust the position of the prosthesis based on real-time vocal feedback. However, with children, this is often difficult to carry out, although there are a few cases that report the use of intraoperative flexible laryngoscope through an LMA to adjust the position of the prosthesis [49, 60]. Another challenge with this laryngeal framework procedure is its effect on the size and continual growth of the pediatric larynx, particularly in very young children [19, 61].

Reinnervation of the paralyzed larynx with a direct neurorrhaphy of the recurrent laryngeal nerve and ansa cervicalis, or less commonly the phrenic nerve, is a much more popular permanent surgical intervention for children with unilateral VFP (Fig. 16.4). It is not performed for return of vocal fold movement but rather to restore tone, prevent atrophy, eliminate aspiration, improve dysphonia, and improve

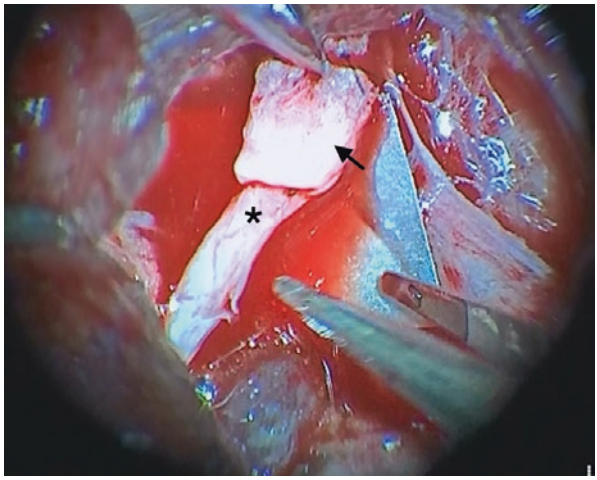

Fig. 16.4 Laryngeal reinnervation. The recurrent laryngeal nerve, depicted by the asterisk, has been anastomosed with the ansa cervicalis, depicted by the arrow

glottal closure [19]. It is recommended that the otolaryngologist perform laryngeal EMG prior to performing the procedure to ensure there is minimal chance of recovery of vocal fold movement [19]. Ansa cervicalis to recurrent laryngeal nerve (ansa-RLN) anastomosis is considered to have superior voice outcomes compared to thyroplasty in patients younger than 52 years of age according to a prospective surgical trial of 24 patients [62]. A single-institution case series of 13 children under the age of 10 who had ansa-RLN anastomosis performed and showed statistically significant improved voice outcomes using the parental global voice rating and GRBAS (grade, roughness, breathiness, asthenia, strain) scale [63]. Importantly, the study also showed statistically significant improvement in parental assessment of dysphagia with liquids [63]. Some authors argue that this procedure is superior to thyroplasty and injection laryngoplasty for several reasons, including no foreign body implant with risk of infection, reproducible results given the standardized technique, lack of a need for intraoperative adjustments, and durability of the procedure [63]. Long-term outcomes have yet to be published.

Conclusion

Some of the controversies and challenges surrounding the treatment of children with VFP include (1) poorly defined indications for surgical intervention, (2) a variety of treatment options without well-documented treatment outcomes, and (3) an inadequate understanding of the natural history of VFP in infants and young children regarding functional long-term effects on swallowing and voice [63]. Studies that focus on objective or subjective swallowing outcomes that include pre- and postsurgical MBS evaluations, FEES, and validated dysphagia surveys are lacking within the literature. Without these data, the choice of management and preferred

surgical intervention are challenging, and the surgeon often relies on level 4 data [49]. Based on the present data, it appears that dysphagia due to VFP can often improve with conservative management, including time and feeding therapy. In those who do not improve, it is the job of the otolaryngologist to determine optimal timing for intervention, as well as the optimal surgical intervention on a patient-by-patient basis.

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