VOL. 9
DECEMBER, 2022

THE PEDIATRIC JOURNEY

Quarterly Newsletter of Pediatric Practice at

El Paso Children's HOSPITAL

STRIDOR AND AIRWAY ANOMALIES

Jonathan Chiao, MD, MPH
PEDIATRIC OTOLARYNGOLOGIST AT EL PASO CHILDREN'S HOSPITAL

Introduction: Stridor is characterized as a harsh or musical whistling sound that results from turbulent airflow in a child's upper airway. When there are obstructive lesions of the airway, the typical laminar airflow pattern becomes disturbed and chaotic. This can be contrasted with stertor which is typically a lower pitched vibratory sound akin to snoring. Turbulent airflow, and thus stridor, can occur during inspiration, expiration, or both – anytime there is air moving in the respiratory system. The initial workup of stridor should be focused on airway stability and assessing the patient's overall respiratory status and providing support as needed. Loudness of stridor is not indicative of the severity - even quiet stridor can be an ominous sign of impending respiratory collapse as the body tires and the airflow velocity decreases.

Airway Dynamics: Poiseuille's Law ($Q = \Delta P \pi r^4 / 8\mu L$) describes the relationship between the flow (Q) of air in the tracheobronchial tree and the cross-sectional radius (r) of the airway. Resistance (1/Q) is therefore inversely proportional to the radius of the airway to the fourth power. A child's subglottis is the narrowest portion of the upper airway, and small changes in its radius can drastically decrease effective airflow to the lower airways. Bernoulli's Principle describes the relationship between intraluminal radial airway pressure and flow velocity as air moves through the system. According to Poiseuille's Law, a narrowed airway will have higher velocity flow and thus by Bernoulli's Principle will have decreased intraluminal radial pressure to keep the airway patent. Increased flow rate, turbulent flow from luminal collapse, and obstructive lesions all create a turbulent flow pattern that results in stridor. This can occur anytime there is air moving in the respiratory tree – inspiration, expiration, or both.

Laryngomalacia: The supraglottis is defined as the space between the lingual epiglottis and the superior most aspect of the vocal folds. Infants have less rigid cartilage structure of the supraglottic larynx, and increased flow velocity which decreases the transluminal pressures, yielding a higher propensity for collapse. This is exacerbated by feeding, supine position, agitation, and anatomic differences such as short aryepiglottic folds that may tether the epiglottis posteriorly causing supraglottic obstruction of the glottic inlet (Figure 1). Additionally, redundant mucosa or arytenoid tissue may physically obstruct the inlet causing turbulence and stridor on inspiration. This is diagnosed with awake fiberoptic laryngoscopy and may be performed at bedside or in the office without sedation. This yields a dynamic assessment of the supraglottic airway and is the gold standard for laryngomalacia diagnosis. Symptomatic onset is traditionally described at 2 weeks of age as the child's respiratory effort increases airway flow velocity, but the physical dimensions of the airway have not substantially increased. This may lead to increased work of breathing, suprasternal tugging, subcostal retractions, and perioral cyanosis. With increased respiratory effort, the caloric expenditure to maintain respiratory homeostasis also increases.

Vocal Fold Immobility (VFI): Children may be born with congenital or later acquire unilateral or bilateral vocal fold immobility. This creates glottic-level obstruction that may present as inspiratory or biphasic stridor. Unilateral VFI is most commonly iatrogenic, but neurologic conditions such as Chiari malformation should also be ruled out. Unilateral VFI is often managed conservatively but requires assessment of the child's ability to protect their airway during swallow. Aspiration is most common with thin liquids, is often silent without cough reflex, and up to 57% of children with unilateral VFI are affected (Irace et al, 2019). Speech may also be affected later in life and characterized by a breathy and pressed voice. Medialization procedures, such as laryngeal reinnervation, can significantly improve voice and patient quality of life. Bilateral VFI may present as an airway emergency. Typically presenting as biphasic stridor, bilateral VFI is often secondary to neurologic or iatrogenic insult. Intubation may be necessary to secure a patent's airway and allow the child to recover function, but tracheostomy may be necessary to bypass the obstruction in approximately 50% of cases. Bilateral selective laryngeal reinnervation is a complex procedure that is performed to restore function and mobility in candidates.

Subglottic stenosis (SGS): The subglottis is located at the level of the cricoid cartilage and is the narrowest part of a child's airway, measuring between 4-7 mm in infants (Holzki et al, 2018). Subglottic measurement of less than 4 mm diameter in an infant is diagnostic of subglottic stenosis (SGS). This commonly presents with inspiratory stridor. While viral infections (e.g., RSV, parainfluenza, croup) cause edema and temporary SGS, more fixed obstructions are most often secondary to iatrogenic injury (e.g., intubation trauma, Figure 2), or anomalies such as hemangiomas, cysts, or cartilage malformations (Figure 3). In older children and

CEO MESSAGE

As 2022 draws to a close, we can take pride in our continuing efforts to deliver the highest standards of healthcare to patients and their families in our region.

This year saw the opening of the new Ear, Nose & Throat clinic, under the medical direction of Dr. Jonathan Chiao, pediatric otolaryngologist, and Dr. Amanda Chiao, Pediatric Hearing and Vestibular Audiologist. We celebrated the grand opening of the Empower Clinic/Rehabilitation Center in the spring. We've also welcomed new staff, including new medical directors for our oncology and NICU departments. Of course, it takes everyone working together to achieve the best outcomes for the families in our community. Thank you for your personal dedication and expertise throughout 2022. With your help, we are poised for make great strides in 2023!

adolescents, SGS typically presents as exertional dyspnea. Endoscopic transoral bronchoscopy is used to evaluate, diagnose, and measure the airway diameter. Treatment of any identified pathology can be provided in a similar fashion. Interventions such as balloon dilation, steroid injection, and laser ablation of stenosis may be performed safely under spontaneous ventilation in the operating room. For more severe SGS, open airway reconstruction may be performed by using costal cartilage autografts to increase the diameter of the stenotic airway.

Conclusions: Stridor is a general term used to describe the sound of turbulent airflow between the supraglottis and bronchial tree. Common childhood pathologies cause characteristic stridor profiles and may be treated by relieving the obstruction responsible for the change in flow dynamics. Appropriate airway support, stabilization, and work-up is essential to preparing the child for advanced intervention and treatment.

For any questions regarding Stridor and Airway Anomalies, please contact our clinic at 915.242.8402

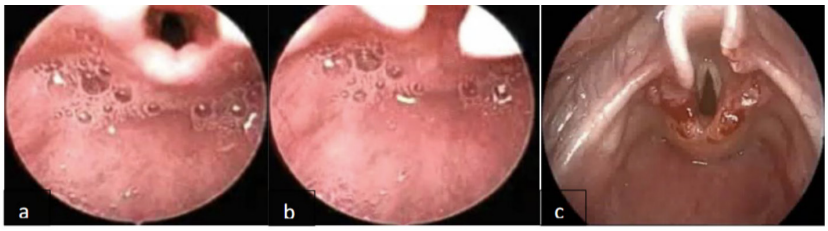


Figure 1: Laryngomalacia. (a) Expiration, (b) Inspiration, and (c) post-supraglottoplasty

Figure 2: Acquired subglottic stenosis from intubation trauma

Bedwell and Zalzal, 2016. Laryngomalacia, Seminars in Pediatric Surgery, 25(3):119-22.

Holzski, Brown, Carroll, and Cote, 2018. The anatomy of the pediatric airway: Has our knowledge changed in 120 years? A review of historic and recent investigations of the anatomy of the pediatric larynx, Pediatric Anesthesia, 28(1):13-22.

Irace, Dombrowski, Kawai, Dodrill, Perez, Hernandez, Davidson, Hseu, Nuss, and Rahbar, 2019. Aspiration in children with unilateral vocal fold paralysis, Laryngoscope, 129(3):569-573.

Mehta and Chiao, 2022. Stridor and Congenital Lesions of the Larynx, Textbook in Press.

PEDIATRIC CORNER

Vanessa Ruiz, MD, FAAP
COMMUNITY PEDIATRICIAN

This year's respiratory season began earlier than usual and with full force. This drive may be attributed to decreased mask use and our decreased exposure to these viruses over the past 2 years. We are experiencing a higher incidence of respiratory syncytial virus (RSV), which has increased the rate of hospitalizations, emergency room (E.R.), urgent care, and physician office visits. We are also seeing an increase in the influenza virus (flu) and COVID-19. We are entering the triple wave as predicted.

We recommend vaccinating your family against influenza and COVID-19 to prevent getting severely ill and decrease infection rates in the community. We also urge you to keep your children at home from school or daycare, if they are beginning to show symptoms of an illness. Hand washing continues to be a major preventive factor in the spread of viruses.

If you are concerned about your child's health status, consult your primary care doctor to advise you on the next steps to take. Our emergency rooms are seeing an influx of patients. We encourage the use of emergency rooms for children who are showing symptoms of severe illness, as mentioned below.

Most children who have RSV will show common cold symptoms. Only 3% of children with RSV will require a hospital stay. When to go to the E.R.?

1. Signs of respiratory distress:
- Fast breathing or shallow breathing
- Flaring of the nostrils
- Head bobbing with breathing
- Grunting during breathing
- Belly breathing, tugging between the ribs and/or the lower neck
- Wheezing

2. A fever that rises above 104°F repeatedly for a child of any age and any fever of 104F and above for infants below 2 months of age.

3. Symptoms of dehydration (urinating less than once every 8 hrs.)

4. Gray or blue color to tongue lips and/or skin

5. Decrease in alertness

6. Poor feeding

We thank you for trusting us with the care of children.

Vanessa Ruiz, M.D.,F.A.A.P.

Reference: Healthychildren.org

VOL. 9
DECEMBER, 2022

THE PEDIATRIC JOURNEY

Quarterly Newsletter of Pediatric Practice at El Paso Children's Hospital

PEDIATRIC VESTIBULAR LOSS: WHO IS AT RISK?

Amanda Chiao, PhD
PEDIATRIC HEARING & VESTIBULAR AUDIOLOGIST AT EL PASO CHILDREN'S HOSPITAL

Introduction: Pediatric dizziness affects a wide range of children, ranging from 10-50%. Common causes of pediatric dizziness span from migraines, to concussions, to other more serious neurological causes including Chiari Malformation. It is also possible for vestibular loss to originate from damage to the inner ear vestibular organs. Thevestibular organs sit closely to the hearing organ and contribute to vestibular reflexes critical for walking and maintaining stable vision with head and body movement. These vestibular organs also send important signals to the eyes and cerebellum. While dizziness may be common, it is important to remember that not every child requires vestibular testing. In fact, true vestibular loss in children typically co-exists with other health factors that are important for parents and pediatric providers to be aware of, and these children would make ideal candidates for pediatric vestibular testing at El Paso Children's Hospital.

Signs and Symptoms: Vestibular disorders can be challenging to recognize in children due to children's inability to describe their symptoms or not reporting typical symptoms like vertigo. However, more common signs and symptoms of vestibular loss (VL) in children can include a description of room spinning, clumsiness (keeping in mind gross motor milestones or comorbidities), not wanting to ride a bike/ swim, or a change in their ability to do so, nystagmus (repetitive, uncontrollable eye movements), difficulty navigating in the dark, significant motion sickness/intolerance, and headaches associated nausea and/or dizziness.

Predictive Factors for Vestibular Loss: Over the past decade, researchers have identified more consistent and predictive risk factors that parents and pediatric providers should be on the lookout for to consider potential VL. Shown in Table 1, the top three risk factors that increase the likelihood for a child to have VL are (Janky et al. 2018):

Parental Concern for gross motor delay: Research has shown a link between high parental concern for physical development and bilateral vestibular loss (when both inner ears are affected) as compared with normal vestibular function. This is particularly evident in children with more than one health co-morbidity as well, suggesting that parent self-report alone may predict significant vestibular loss in a child; however, not likely mild-moderate levels of vestibular loss, such as when the damage just affects one inner ear in total or in partial.

Delay in the child's ability to sit and walk: The vestibular organs in the inner ear contribute to important vestibular reflexes that control aspects of neck and trunk control, both of which are important for sitting, standing, and walking independently (De Kegel et al., 2012; Inoue et al., 2013). These organs develop during the first trimester of pregnancy and are typically mature by birth. Research has shown that children who have known vestibular loss are delayed in their ability to sit independently by about 7.25 months or walk later than 14.5 months.

Diagnosed hearing loss: Due to the close anatomical proximity and shared vascular supply of the hearing and the vestibular organs in the inner ear, etiologies that affect hearing also may affect the vestibular system, particularly since the vestibular and hearing organs develop at a similar trajectory during embryology. Pediatric vestibular loss that may be congenital are often found in Pendred or CHARGE syndromes, Usher Types 1 and 3, and Waardenburg syndrome. However, vestibular loss may be acquired after birth and associated with meningitis and cytomegalovirus (Cushing et al 2013). It has been identified that the more significant the child's degree of hearing loss is, the higher the odds of that child to have vestibular loss. Thus, children with profound hearing loss and/or have cochlear implants are of particular risk (Cushing et al., 2008)

Testing: Often, the identification of vestibular loss requires a description from the childcaregiver, clinical observation from a professional, and objective vestibular testing by an audiologist. Figure 1 highlights some of the types of testing a child may perform during their vestibular evaluation. The main purpose of vestibular testing is to measure a child's ocular motor ability (how they can move their eyes) and a measure of nystagmus. Other more functional assessments can be performed including dynamic visual acuity (how well a child can view objects with head movement) and balance testing. Because many of the vestibular reflexes are developed by birth, select pediatric vestibular assessments can be achieved in full term infants as young as 5 days, with reliability increasing as early as 6 months, and fully adult-like responses by age 4 (Janky and Rodriguez, 2018). In fact, because of the high comorbidity of vestibular loss in children with hearing loss, a vestibular screening is currently being implemented with the established newborn hearing screening programs internationally and may be on the rise in the United States in the future.

Prognosis and Treatment: Children with vestibular loss who do not receive interventions may not spontaneously catch up to their peers for gross motor development, which could lead to greater fall risk, reduced quality of life, and/or less participation in sports or activities. Emerging evidence also suggests that children with vestibular loss may also have visual-spatial processing delays which could affect math and reading abilities. Depending on the cause of a child's dizziness or VL, rehabilitative and/or medical interventions can be utilized. For children with vestibular loss, a form of physical therapy referred to as vestibular rehabilitation is considered the gold-standard and includes retraining the eyes to respond with active head and body movement. Vestibular rehabilitation can mimic realistic activities that are fun and motivating for young children and adolescents including playing video games with head movement, balancing, and reading.

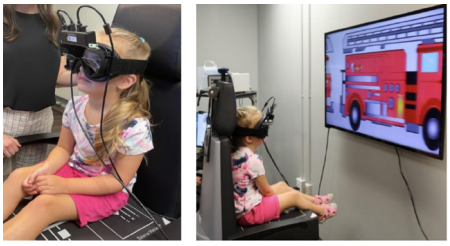
In summary, pediatric dizziness is common but in some cases can stem from true inner ear vestibular loss. While vestibular testing can be helpful for children post-concussion and migraine with dizziness, a referral for vestibular evaluation should be especially considered for children with hearing loss that is greater than moderately severe and particularly for those children who sit later than 7.25 months or walk later than 14.5 months or whose parents report concerns for gross motor development delay.

For any questions regarding Pediatric Vestibular Loss, an assessment or a consultation, please contact our clinic at 915-242-8423.

Table 1: Three top risk factors for pediatric vestibular loss

Risk Factor	Specifics
Parental concerns for gross motor delay	Concern with the presence of comorbidity is linked to more signifi-cant vestibular loss
Delatey milestones for sitting and walking	Sit later than 7.25 months or walk later than 14.5 months
Diagnosed hearing loss	Greater degrees of hearing loss increase chances for also having vestibular loss

Videonystagmography



Balance & Visual Testing

Cushing, S. L., Papsin, B. C., Rutka, J. A., James, A. L., & Gordon, K. A. (2008). Evidence of vestibular and balance dysfunction in children with profound sensorineural hearing loss, Laryngoscope, 118, 1814–1823.

De Kegel, A., Maes, L., Baetens, T., Dhooge, I., & Van, W. H. (2012). The influence of a vestibular dysfunction on the motor development of hearing-impaired children. Laryngoscope, 122, 2837–2843.

Inoue, A., Iwasaki, S., Ushio, M., Chihara, Y., Fujimoto, C., Egami, N., & Yamasoba, T. (2013). Effect of vestibular dysfunction on the development of gross motor function in children with profound hearing loss. Audiology & Neuro-otology,18, 143–151.

Janky, K. L., Thomas, M., High, R. R., Schmid, K. K., & Ogun, O. A. (2018). Predictive Factors for Vestibular Loss in Children with Hearing Loss. American journal of audiology, 27(1), 137–146. https://doi.org/10.1044/2017_AJA-17-0058

Rine, R. M., Braswell, J., Fisher, D., Joyce, K., Kalar, K., & Shaffer, M. (2004). Improvement of motor development and postural control following intervention in children with sensorineural hearing loss and vestibular impairment. International Journal of Pediatric Otorhinolaryngology, 68, 1141–1148.

VOL. 9
DECEMBER, 2022

THE PEDIATRIC JOURNEY

Quarterly Newsletter of Pediatric Practice at El Paso Children's Hospital

CMO CORNER

The whole world is experiencing a surge in respiratory infections. Children's hospitals were relatively insulated during the COVID-19 pandemic, as most children were not severely ill. Now we are seeing a marked increase in respiratory hospitalizations, in the general pediatric ward and in the pediatric intensive care unit.

Respiratory syncytial virus is causing a tremendous strain on every hospital. Premature babies, chronic lung disease children, and children with congenital heart disease are at highest risk. Certain infants are eligible for palivizumab (Synagis) which is a monoclonal antibody given monthly by injection. Unfortunately, no vaccine is available for RSV.

To a lesser degree, influenza is also important. Fortunately, we do have a seasonal vaccine against the flu. There are also two specific treatment for influenza: Oseltaminivir (Tamiflu) and Zanamivir (Relenza). The first is given orally and the second is given by inhalation. Tamiflu is approved for patients 2 weeks and older. Relenza is approved for patients 7 years or older.

The whole world can do other measures to reduce this problem. Get a flu shot! Wash your hands frequently! Stay home if you get sick. Cover your cough! And, be safe.

2023 CME SESSIONS

Jan 12-14 Symposium on Cleft Lip and Palate Deformities

Jan 8 In-person CME with Dr. Panda-NICU Medical Director

- **Topic: NICU**

Jan 12 Virtual CME with Dr. Alam-Pediatric Urologist

- **Topic: TBD**

Jan 25 Virtual CME with Dr. Panda-NICU Medical Director

- **Topic: NICU**

Feb 2 Virtual CME with Dr. Lopez-Neuropsychologist

- **Topic: TBD**

EL PASO CHILDREN'S HOSPITAL NEW APPOINTMENTS & PROVIDERS

- **Sanjeet K. Panda, MD-New Medical Director of the Laura & Pat Gordon Family Advanced Level IV NICU**
- **Michael Rytting, MD-New Medical Director of the Southwest University Pediatric Blood and Cancer Center**
- **Jonathan Chiao, MD-Onboarding Pediatric Otolaryngologist**
- **Amanda Chiao, PhD-Onboarding Pediatric Hearing & Vestibular Audiologist**
- **Simone Chang, MD-Onboarding Pediatric Hematologist/Oncologist**
- **Ijeoma Ibeanu, MD- Onboarding Child & Adolescent Psychiatrist**
- **Abraham Lopez, PhD- Onboarding Neuropsychologist**
- **Deyanira Zambrano, NP- Onboarding Nurse Practitioner for the Behavioral Clinic**

PEDIATRIC JOURNEY EDITORIAL BOARD

For any topic suggestions on future editions, please email *marketing@elpasochildrens.org*