International Journal of Contemporary Pediatrics
Swain SK. Int J Contemp Pediatr. 2023 Jan;10(1):107-113
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20223432

Review Article

Evaluation of the pediatric airway: a review

Santosh Kumar Swain*

Department of Otorhinolaryngology and Head and Neck Surgery, IMS and SUM hospital, Siksha "O" Anusandhan University, Bhubaneswar, Odisha, India

Received: 07 November 2022
Accepted: 03 December 2022

***Correspondence:**
Dr. Santosh Kumar Swain,
E-mail: santoshvoltaire@yahoo.co.in

ABSTRACT

The airway in the pediatric age group is a complex structure that extends from the external nares to the junction of the larynx and trachea. The airway of pediatric patients has significant anatomical and physiological differences compared to the adult age group. The difficult airway in children is an important contributor to both morbidity and mortality of the patient. The symptoms and signs of pediatric patients with respiratory distress depend on the site and severity of the obstruction. It is essential to evaluate and localize the site and etiology of the obstruction of the pediatric airway. Pediatric otolaryngologists and anesthetists must have a strategy for managing the predicted difficult pediatric airway. Flexible nasopharyngolaryngoscopy is the gold standard method for predicting or knowing the difficult airway in children. The majority of pediatric patients who have difficult airways are identified preoperatively. Knowledge of the airway differences between the pediatric and adult ages will help clinicians anticipate and troubleshoot difficulties that may happen. This review article aims to discuss the evaluation of the pediatric airway including its anatomy and physiology of the airway, proper history taking, clinical examination, and investigations.

Keywords: Pediatric airway, Larynx, Trachea, Flexible nasopharyngolaryngoscopy, Laryngomalacia

INTRODUCTION

The airway is a vital part of the human body and failure to secure a patient's airway can lead to severe and long-standing consequences, including death.[1] Anticipating and preparing for difficulty in airway management is usually crucial to avoid airway catastrophes. Proper evaluation of the airway is done less commonly in children than the adult patients.[2] There are several key differences between the anatomy and physiology of the pediatric and adult airway. Predicting the difficult airway at the pediatric age requires adequate history, proper clinical examination, and reviewing the relevant investigation.[3] The airway of the pediatric age has a number of significant differences when compared to the adult age and presents some unique challenges. Awareness of the anatomical and physiological differences and important clinical conditions affecting the children will allow the clinicians to formulate and execute safe and effective management of the pediatric airway. The purpose of this review article is to review the evaluation of the pediatric airway.

METHODS OF LITERATURE SEARCH

Multiple systematic methods were used to find current research publications on the evaluation of the pediatric airway. We started by searching the Scopus, PubMed, Medline, and Google Scholar databases online. A search strategy using PRISMA (Preferred reporting items for systematic reviews and meta-analysis) guidelines was developed. This search strategy recognized the abstracts of published articles, while other research articles were discovered manually from the citations. Randomized controlled studies, observational studies, comparative studies, case series, and case reports were evaluated for eligibility. There were a total number of articles 72 (22 case reports; 18 cases series; 32 original articles) (Figure 1). This paper focuses only on the details of the evaluation of the pediatric airway. This review article

describes the anatomy and physiology of the pediatric airway, its history, clinical examinations, and investigations of the pediatric airway. This analysis provides a better understanding of the evaluation of the pediatric airway and its clinical profile along with its management. It will also serve as a catalyst for further study of the evaluation of the pediatric airway and the development of newer methods for the evaluation of the pediatric airway.

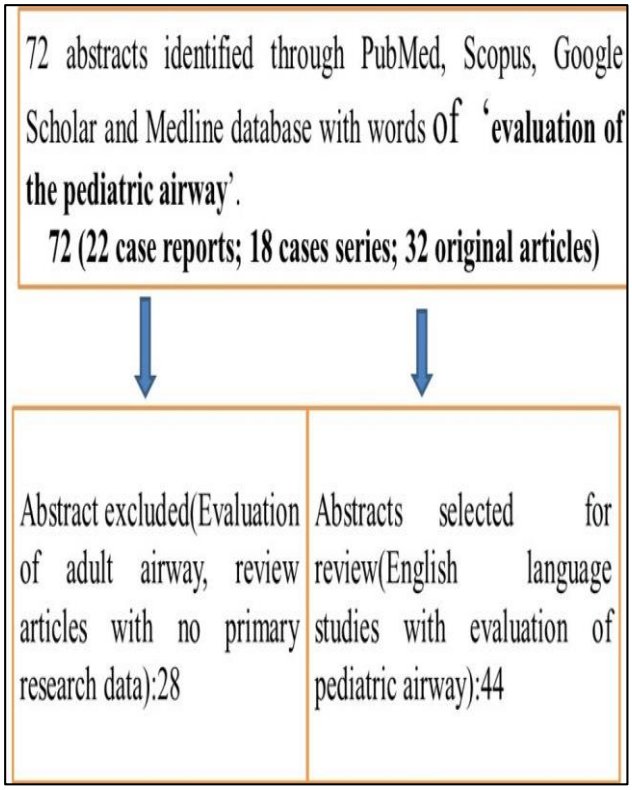

Figure 1: Flow chart showing methods of literature search.

ANATOMY OF PEDIATRIC AIRWAY

The upper airway extends from the external nares to the junction of the larynx with the trachea. It includes the nose, the paranasal sinuses, the pharynx, and the larynx.[4] The patency of the airway is critically important in the anesthetized patient as well as the patient who is unconscious for any reasons.[5] The pediatric airway differs from the adult airway particularly in infancy, with differences becoming much less marked as the child grows older.[6] The tongue is usually larger and mandible shorter in the young children. The infants are obligate nasal breathers until the age of 5 months.[6] There are prominent tonsils and adenoids seen in preschool-age children and these are a common reason for elective surgery.[7] In children, the larynx is relatively higher in the neck in comparison to the adult age group. The cricoid ring is found approximately at the level of the C4 vertebrae at birth, C5 at the age of 6 years, and C6 at adult age. [8] The epiglottis in pediatric age is more U shaped in comparison to adult age and it is less in line with the trachea and may lie across the glottic opening.[8] Vocal folds are not usually found at a right angle (90^0) to the trachea. The vocal folds are angled in an anterior-inferior to posterior-superior fashion.[9] This typically does not affect the laryngoscopic view, it can cause insertion of the endotracheal tube more challenging or more traumatic. The hypopharynx of the children is relatively shorter in height and narrower in width. On cross-section, the airway of an adult person is more elliptical than a child's airway.[10] This implies the supraglottic airway.

PEDIATRIC AIRWAY PHYSIOLOGY

The important physiological feature of the infant is the high metabolic rate that needs a high minute oxygen consumption (7 ml/kg/min compared to 3 ml/kg/min in the adult age).[11] The tidal volume of the infant is relatively fixed due to the anatomic structure of the thorax. So, in infants, an increase in respiratory rate more effectively increases the minute alveolar ventilation than does an increase in the tidal volume.[11] A progressive increase in the respiratory rate in infants is indicative of physiological stress and may portend apnea. The ratio of minute alveolar ventilation to functional residual capacity is quite high in infants. Arterial oxygen saturation consequently decreases precipitously after the onset of apnea.[11] The patency of the airway is vital in the anesthetized patient and also in any patient who is unconscious from any cause.[12] Factors which reduce the lumen of the pharynx, increase pressure around the pharynx, reduce the pressure inside the pharyngeal lumen, or that make the pharyngeal walls more compliant will result in obstruction of the airway during sleep, sedation, and anesthesia.[13]

CLINICAL EVALUATION OF THE PEDIATRIC AIRWAY

History

The initial airway assessment starts with a good history. Questions should be directed toward eliciting the indications of a potentially difficult airway. Assessment of the pediatric airway should start with inquiries about the medical history of the child including details of birth and subsequent development. The previous respiratory diseases should be documented, along with the history of any trauma or surgical interventions in the airway. Any complications that happened during previous anesthesia particularly those related to the airway should be noted. Specific questions should be asked to the parents of the children about the child's respiration, feeding, and phonation as well as the presence of cough and its nature. Noisy breathing usually indicates abnormalities in the pediatric airway.[14] Enlarged tonsils and adenoids are often associated with snoring and hyponasal speech.[15] Nasal obstruction and an impaired sense of smell found without rhinorrhoea may be consistent with enlarged adenoids. A history of cessation of breathing or excessive

daytime sleep of the child indicates obstructive sleep apnea. A history of apnea along with cyanosis or signs of respiratory obstruction may be associated with choanal atresia.[16] Abnormal feeding patterns along with respiratory insufficiency in infants, particularly associated with aspirations as suggested by coughing, chocking and vomiting.[15] Enquiries about the voice and cry of the child can give valuable information about the airway. Hoarseness of voice or diminished cry are important signs of laryngomalacia. Changes in the quality of the voice are found in cases of unilateral vocal fold paralysis.[15] Cough is usually a symptom of respiratory diseases and is often related to respiratory tract infection. Cough occurs by stimuli originating in the mucosal lining of the respiratory tract.[17] The severity, frequency, and character of the cough are dependent on multiple factors such as nature and situation of the lesion responsible for cough, presence or absence of sputum and association of coexisting abnormalities like impairment of ventilator function.[18] Cough is often productive and associated with purulent nasal secretions in case of acute respiratory tract infection. In absence of infections, a croup-like cough may suggest subglottic stenosis.[15] In absence of systemic illness, sudden onset of cough suggests inhalation of a foreign body.

Examination

The idea of the pediatric airway can be obtained from the general appearance of the child with respect to body mass index and characteristics of the face. Failure to thrive is an important complication of obstructive sleep-disordered breathing particularly when the cause is adenotonsillar hypertrophy.[19] Respiratory function and airway abnormalities are often seen in obese children and may suggest obstructive sleep apnea.[20] One study showed that obesity is an important predictor for upper airway obstruction during sleep.[21] The role of body mass index for upper airway obstruction among Caucasian children is much milder than that typically seen among African-American children.[21]Presence of nasal flaring may suggest the respiratory distress. Drooling of the saliva or mouth breathing often seen in children with enlarged adenoids or tonsils.[22] The mucous membranes of the child are usually checked for detecting cyanosis due to hypoxemia. The voice of the child or cry should be documented, because hoarseness or a weak cry may be observed in case of airway obstruction at the level of the vocal folds. The stridor is a high-pitched sound suggestive of laryngeal or tracheal obstruction. The inspiratory type of stridor indicates obstruction at or above the upper part of the trachea, as the extrathoracic obstruction is aggravated by negative intrathoracic pressure created at the time of inspiration.[23] The expiratory stridor is indicative of obstruction at the lower trachea or bronchi, exacerbated by the compression of the airways during forced expiration. In the case of laryngomalacia, there is excessive flaccidity of the epiglottis and loss of aryepiglottic folds which cause these structures to collapse during inspiration and leads to stridor. This laryngeal collapse is exacerbated during crying because of the greater effort, leading to the increased collapse of the soft supraglottic structures. Inhalation of the induction anesthesia usually causes a reduction in the stridor in the case of laryngomalacia due to a decrease in the force of the respiratory movements.[24]

Imaging

Radiological assessment of the airway provides non-invasive data on the structure of the pediatric airway. Standard imaging provides information regarding the anatomy of the pediatric airway, with fluoroscopy being an additional tool. Cephalometric radiography is helpful to study the relationships between the bony and soft tissue landmarks.[25] Currently, computed tomography (CT) scans and magnetic resonance imaging (MRI) have been useful for providing anatomical details comparable with endoscopy.[26]

Endoscopic evaluation

The endoscopy of the pediatric airway can be done by the use of either fibreoptic or rigid endoscopes. Flexible nasopharyngolaryngoscopy can be performed even in neonates using a small caliber fiberscope. It can be performed even without general anesthesia, with the application of local anesthesia to the nasal cavity. Flexible nasopharyngolaryngoscopy can be performed with or without the help of general anesthesia and provides views of the bilateral nasal cavities, choanae, pharynx, and larynx in all age groups.[27] It also provides dynamic views of the laryngeal and upper airway function. Rigid bronchoscopy is usually performed under general anesthesia in children. Direct micro laryngoscopy with suspension laryngoscope needs general anesthesia and allows detailed examination of the pharynx and larynx.

Sleep evaluation

The sleep disorders include snoring, upper airway resistance syndrome, obstructive hypopnea syndrome, and obstructive sleep apnea. Polysomnography is considered the best study to confirm the severity of the sleep disorder in the pediatric age group.[28]Upper airway pressure flow measurement may be helpful for evaluation of the upper airway function.[29] Sleep naso-endoscopy is helpful to determine the site of obstruction during the sleep of the child.

Lung function evaluation

Lung function tests are helpful for the assessment of the pediatric airway. Evaluation of the ventilatory mechanics including assessment of forced expiration and measurements obtained by spirometry. Pulse oximetry gives an accurate assessment of arterial oxygenation in absence of shock or poor perfusion and it provides an accurate assessment of arterial oxygenation in children of

all ages.[30] Measurement of transcutaneous oxygen is reasonably accurate in the new-born infant, however less accurate in older child.[31]Arterial blood gas (ABG) measurement is sometimes helpful in physiological compromise, specifically in conditions of chronic airway obstruction and compensated respiratory acidosis. Arterial puncture is usually traumatic for children and may aggravate any underlying airway obstruction as a result of dynamic airway collapse.[32] Assessment of capillary blood may be helpful in some cases.

PREDICTION OF THE DIFFICULT PEDIATRIC AIRWAY

A difficult airway is defined as one where an experienced provider encounters or anticipates difficulty with any or all face mask ventilation, direct or indirect (e.g., video laryngoscopy), supraglottic device use, tracheal intubation, or surgical airway.[33] Knowledge of the normal anatomy of the pediatric airway and an understanding of the congenital anomalies of the airway are important aspects of safe airway management in pediatric patients. A history and clinical examination are important to predict the difficult airway and planning for the unexpectedly difficult airway of pediatric patients. The pre-existing risk factors include bronchial asthma, wheezing, upper respiratory tract infections, snoring and passive smoking are associated with critical respiratory events and this trend is usually caused by functional airway devices.[34] pediatric airway difficulty is often caused by functional airway problems. This group of patients is pediatric individuals with aspirated foreign bodies, laryngospasm, tonsillar hypertrophy, bronchospasm, ineffective head positioning, and muscle or laryngeal rigidity due to opioids.[35] Congenital anomalies like ear abnormality can suggest a defect in the embryonic development of the first branchial arch, leading to micrognathia and airway management difficulty. High Mallampati score is an important predictor of a difficult airway with limited mouth opening, retrognathia, dysmorphic features, reduced neck mobility, and inability to prognathy.[36] The signs of the compromised airway include stridor, tachypnoea, use of accessory muscles, absent or weak cry, and history of sleep apnea of difficulty with breathing at the time feeding.

CLINICAL CONDITIONS WITH ANOMALY IN PEDIATRIC AIRWAY

Upper airway obstruction can occur at different anatomical levels. New-borns may present with choanal atresia. Both retroglossal and palatal obstruction may occur in infants.[37] Children with obstructive sleep apnea often have choanal atresia, adenoid and tonsillar hypertrophy, subglottic stenosis (Table 1), subglottic hemangioma, airway masses, and vascular compression are other important causes of airway obstruction in children.[38]

Table 1: Myer-Cotton grading system for subglottic stenosis.

Grading	Level of subglottic airway obstruction
Grade I	No obstruction to 50% obstruction
Grade II	51% obstruction to 70% obstruction
Grade III	71% obstruction to 99% obstruction
Grade IV	No detectable lumen

Choanal atresia

Choanal atresia is thought to be a consequence of the persistence of the nasal buccal membrane. The obstruction in the choanal atresia may be membranous, bony, or a combination of both, with the latter being the most commonly found. Choanal atresia may be unilateral or bilateral and the ratio of unilateral to bilateral cases is usually 1:1.[39] Choanal atresia may be associated with a number of congenital anomalies. The important association is with CHARGE syndrome (coloboma, heart defects, atresia, retardation of growth and development, genitourinary disorders, and ear abnormalities.[39] Neonates are obligate nasal breathers during the first six weeks of life. Any obstruction in the nose and nasopharynx of the neonates can manifest with apnea.[40] This is not seen when neonates are upset as they mouth breath during crying. Complete obstruction of the posterior nasal airway by choanal atresia does not allow drainage of the nasal secretions into the nasopharynx. These nasal secretions passively drain anteriorly and characteristically copious and tenacious. Choanal atresia is suspected when a 6-Fr suction catheter could not be passed through the nose into the nasopharynx. A flexible nasal endoscope (1.9 mm) is helpful to confirm the choanal atresia.[41] CT scans with axial cuts are performed to know the choanal atresia and sometimes genetic evaluation can be undertaken.[41]

Laryngomalacia

Laryngomalacia is the most common cause of stridor in infants.[42] It has been thought to occur more commonly in term males with normal birth weight, although recent evidence suggests that it is equally common in females. High-risk infants for laryngomalacia include premature Hispanic infants and black infants of all gestational ages.[43] The new born with laryngomalacia typically develops intermittent inspiratory stridor within the first two weeks of life, which resolves slowly over several months.[43] The median time to spontaneous resolution of the stridor in laryngomalacia is 7 to 9 months of age, and the majority will show no stridor by 18 months of age. In laryngomalacia, the stridor often worsens with feeding, and the infant need to take breaks while feeding to breathe.[44] The stridor in the case of mild laryngomalacia usually improves with crying, as the tone of the pharynx is increased; conversely, in case of moderate to severe laryngomalacia, the stridor typically worsens with crying due to increased airflow through the severely collapsed larynx. In the case of infants with severe laryngomalacia,

infants have been found to have shorter aryepiglottic folds in comparison with infants without laryngomalacia. Laryngomalacia is also seen as an isolated finding in healthy infants or it may be associated with other disorders such as cerebral palsy.[44]

Vocal fold paralysis

Vocal fold paralysis is the second most common cause of stridor in neonates.[45] The diagnosis of vocal fold paralysis is usually established by performing awake flexible transnasal fiberopticlaryngoscopy.[46] This clinical entity can be divided into congenital and acquired vocal fold paralysis and unilateral and bilateral paralysis. Bilateral vocal fold paralysis is usually present at birth, whereas unilateral vocal fold paralysis is an acquired condition that occurs as a result of injury to the recurrent laryngeal nerve.[47] Due to the longer length and course of the left recurrent laryngeal nerve, this is more likely to be injured than the right recurrent laryngeal nerve. So, acquired paralysis often affects the left vocal fold. The risk factors for acquired vocal fold paralysis include oesophageal surgery, tracheoesophageal fistula repair, ductus arteriosus repair, and thyroid surgery. The congenital vocal fold paralysis is usually idiopathic and seen in central nervous system pathology like hydrocephalus and Chiari malformation of the brainstem.[47] Most of the children with bilateral vocal fold paralysis present with airway compromise, though with an excellent voice. These children do not aspirate. Majority of infants affected bilaterally require tracheostomy.[48] However, children with unilateral vocal fold paralysis have an acceptable airway, but a breathy voice. They are at a slightly higher risk for aspiration. Up to 50% of the children with congenital idiopathic bilateral vocal fold paralysis have spontaneous resolution of their paralysis by one year of age.[49]

Laryngeal web

Laryngeal web occurs due to a failure of recanalization of the glottic airway in the early part of the embryogenesis.[50] The severity of symptoms in laryngeal webs include dyspnea and voice changes which correlates with the size and position of the web.[51] The glottic webs are virtually anteriorly, with varying degrees of the glottic airway compromise, and often manifest in an abnormal cry or respiratory distress.

CONCLUSION

Airway management of pediatric patients differs from that of the adult age group and needs special attention. Knowledge of the unique features of pediatric airway anatomy and physiology can reduce the risk of adverse airway events when applied to clinical practice. Successful management of the pediatric airway depends on careful evaluation of the airway in pediatric patients. The evaluation of the airway always should proceed in a logical and orderly fashion. Good airway management in pediatric patients is an essential skill for clinicians in most specialties. Adequate evaluation of the pediatric airway can play an important role in reducing the risks associated with difficult airway management.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Swain SK, Choudhury J, Dubey D. Open safety pin in the pediatric airway: our experiences at a tertiary care teaching hospital. MGM J Med Sci. 2022;9(3):356-61.
2. Krishna SG, Bryant JF, Tobias JD. Management of the difficult airway in the pediatric patient. J Pediatr Intensive Care. 2018;7(03):115-25.
3. Swain SK, Behera IC, Sahoo L. Pediatric Laryngeal papillomatosis: Experiences at an Indian teaching hospital. J Heal Res Rev. 2019;6(3):114-121.
4. Hillman DR, Platt PR, Eastwood PR. The upper airway during anaesthesia. Bri J Anaesth. 2003;91(1):31-9.
5. Drummond GB. Controlling the airway-Skill and science. Anesthesiology. 2002; 97:771-3.
6. Engelhardt T, Fiadjoe JE, Weiss M, Baker P, Bew S, Echeverry Marín P et al. A framework for the management of the pediatric airway. Pediatr Anesth. 2019;29(10):985-92.
7. Sunder RA, Haile DT, Farrell PT, Sharma A. Pediatric airway management: Current practices and future directions. Paediatr Anaesth. 2012;22:1008-15.
8. Adewale L. Anatomy and assessment of the pediatric airway. Paediatr Anaesth. 2009;19(1):1-8.
9. Carr RJ, Beebe DS, Belani KG. The difficult pediatric airway. Sem Anesth Perioper Med Pain. 2001;20:219-27.
10. Abramson Z, Susarla S, Troulis M, Kaban L. Age-related changes of the upper airway assessed by 3-dimensional computed tomography. J Craniofac Surg. 2009;20(1):657-63.
11. Wood RE. Evaluation of the upper airway in children. Current Opin Pediatr. 2008;20(3):266-71.
12. Hung OR, Morris I: Dynamic anatomy of upper airway: Anessential paradigm. Can J Anaesth. 2000;47:295-8.
13. Dave MH, Kemper M, Schmidt AR, Both CP, Weiss M. Pediatric airway dimensions-a summary and presentation of existing data. Pediatr Anesth. 2019;29(8):782-9.
14. Swain SK, Sahu MC. Laryngeal Carcinoma in a Pediatric Patient-A Case Report. Iran J Otorhinolaryngol. 2019;31(105):251-5.
15. Wang J, Zhao Y, Yang W, Shen T, Xue P, Yan X et al. Correlations between obstructive sleep apnea and adenotonsillar hypertrophy in children of different weight status. Scientific Rep. 2019;9(1):1-7.

16. Holzman R. Anatomy and embryology of the paediatric airway. Anesthesiol Clin North America. 1998;16:707-27.
17. Swain SK, Behera IC, Mohanty JN. Laryngeal manifestation due to smoking among the pediatric age group–Our experiences at an Indian teaching hospital. Arch Med Heal Sci. 2019;7(2):186-90.
18. Swain SK, Mallik KC. Ear, nose, and throat foreign bodies in pediatric age. Med J Babylon. 2020;17(3):238-43.
19. Shorten GD, Opie NJ, Graziotti P, Morris I, Khangure M. Assessment of upper airway anatomy in awake, sedated and anaesthetised patients using magnetic resonance imaging. Anaesth Intens Care. 1994;22(2):165-9.
20. Ray RM, Senders CW. Airway management in the obese child. Pediatr Clin North Am. 2001;48:1055-63.
21. Kohler M, Lushington K, Couper R, Martin J, van den Heuvel C, Pamula Y et al. Obesity and risk of sleep related upper airway obstruction in Caucasian children. J Clin Sleep Med. 2008;4(2):129-36.
22. Swain SK, Sahu MC, Choudhury J, Ananda N. Adenotonsillectomy affecting quality of life in pediatric patients: Our experiences at a tertiary care teaching hospital of Eastern India. Ann Ind Academy Otorhinolaryngol Head Neck Surg. 2020;4(1):1-4.
23. Swain SK, Sahu MC, Choudhury J. Subglottic stenosis in paediatric patients. Pediatr Polska-Polish J Paediatr. 2018;93(1):80-5.
24. Roberts JT. Clinical Management of the Airway. Philadelphia, PA: W.B. Saunders Company. 1994.
25. Kawashima S, Niikuni N, Chia-hung L, Takahasi Y, Kohno M, Nakajima I et al. Cephalometric comparisons of craniofacial and upper airway structures in young children with obstructive sleep apnea syndrome. Ear Nose and Throat J. 2000;79(7):499-506.
26. Bradshaw K. Imaging the upper airways. Paediatr Respir Rev. 2001;2:46-56.
27. Swain SK, Behera IC. Performing laryngotracheobronchial procedure in coronavirus disease 2019 pandemic: A highly aerosol generating event in clinical practice. Matrix Sci Medica. 2021;5(1):1-6.
28. Rundo JV, Downey III R. Polysomnography. Handbook of clinical neurology. 2019; 160:381-92.
29. Cauldfield H. Investigations in paediatric obstructive sleepapnoea: do we need them? Int J Pediatr Otorhinolaryngol. 2003;67:(1):107-10.
30. Swain SK, Bhattacharyya B, Mohanty JN. Plastic bronchitis mimicking with foreign body bronchus in pediatric patient-A review. Indian J Child Heal. 2019;6(9):465-9.
31. Eisenberg JD, Wall MA. Pulmonary function testing in children. Clin Chest Med. 1987;8:666.
32. Wheeler M, Cote CJ, Todres ID, The Pediatric Airway in Cote CJ, Lerman J, Todres ID et al. eds. A Practice of Anaesthesia for Infants and Children, 4th edn. Philadelphia, PA: Saunders Elsevier. 2009;237-73.
33. Law JA, Broemling N, Cooper RM, Drolet P, Duggan LV, Griesdale DE et al. The difficult airway with recommendations for management–part 1-difficult tracheal intubation encountered in an unconscious/induced patient. Can J Anesth. 2013;60(11):1089-118.
34. Engelhardt T, Virág K, Veyckemans F, Habre W. Airway management in paediatric anaesthesia in Europe-insights from APRICOT (Anaesthesia Practice in Children Observational Trial): a prospective multicentre observational study in 261 hospitals in Europe. Bri J Anaesth. 2018;121(1):66-75.
35. Zalzal GH. Pediatric stridor and airway compromise. Le J Med Libanais. 1994;42(4):221-6.
36. Swain SK, Sahu MC, Mohanty S, Samal R, Baisakh MR. Management of laryngotracheal stenosis-Still remains a challenge for successful outcome. Apollo Med. 2016;13(2):102-7.
37. Don GW, Kirjavainen T, Broome C, Seton C, Waters KA. Site and mechanics of spontaneous, sleep-associated obstructive apnea in infants. J Applied Physiol. 2000;89(6):2453-62.
38. Rudman DT, Elmaraghy CA, Shiels WE, Wiet GJ. The role of airway fluoroscopy in the evaluation of stridor in children. Arch Otolaryngol Head Neck Surg. 2003;129(3):305-9.
39. Keller JL, Kacker A. Choanal atresia, CHARGE association, and congenital nasal stenosis. Otolaryngol Clin North Am. 2000;33:1343-51.
40. Swain SK, Choudhury J. Pediatric airway diseases. Ind J Heal Sci Biomed Res. 2019;12(3):196-201.
41. Swain SK, Sahu MC, Jena A. Congenital choanal atresia: our experiences in a tertiary care teaching hospital in eastern India. Pediatr Polska-Polish J Paediatr. 2018;93(1):57-61.
42. Swain SK, Das A, Behera IC, Bhattacharyya B. Tracheostomy among pediatric patients: A review. Ind J Child Heal. 2018;5(9):557-61.
43. Scott BL, Lam D, MacArthur C. Laryngomalacia and swallow dysfunction. Ear Nose Throat J. 2019;98(10):613-6.
44. Hassan MM, Emam AM, Mahmoud AM, Awad AH, Rezk I, Abou-Taleb A et al. Congenital laryngomalacia: Is it an inflammatory disease? The role of vitamin D. Laryngoscope. 2020;130(2):448-53.
45. Swain SK. Pediatric tracheostomy: a review. Int J Contemporary Pediatr. 2022;9(2):218-23.
46. Swain SK, Choudhury J. Experience with the management of pediatric laryngopharyngeal reflux in an Indian teaching hospital. J Clin Sci. 2020;17(3):61-5.
47. Giotakis AI, Pototschnig C. Prognosis of congenital idiopathic abductor laryngeal paralysis with laryngeal electromyography. Laryngoscope. 2020;130(4):252-7.

48. Swain SK, Behera IC. Pediatric tracheostomy: A 10-year experience at a tertiary care teaching hospital in Eastern India. Ind J Heal Sci Biomed Res. 2022;15(3):224-9.
49. Ryan MA, Upchurch PA, Senekki-Florent P. Neonatal vocal fold paralysis. Neo Rev. 2020;21(5):308-22.
50. Swain SK, Das A, Sahu MC. Isolated laryngeal tuberculosis in a 10-year-old boy: A case report. Pediatr Polska-Polish J Paediatr. 2018;93(3):280-3.
51. Swain SK, Nahak B, Sahoo L, Munjal S, Sahu MC. Pediatric dysphonia-a review. Ind J Child Heal. 2019;6(1):1-5.

Cite this article as: Swain SK. Evaluation of the pediatric airway: a review. Int J Contemp Pediatr 2023;10:107-13.