Endoscopic Sinus Surgery in Pediatric Patients

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68.1 Introduction

Endoscopic sinus surgery (ESC) is a surgical technique that has been safely performed on children since the 1980s. Although the anatomical structures are similar to those of the adult anatomy, the small size of the area involved, the anatomical structures and barriers being thinner and fragile, and various surgical indications all mean that these require special surgical equipment, scrupulous anatomical investigation, and good surgical experience. Endoscopic surgery in children is difficult and it is more difficult to establish surgical indication. The inability to perform regular symptomatic questioning in children and difficulty of examination also make the decision to operate problematic. The possibility of comprehensive surgery inside the nose causing impairment to the developing facial skeletal structure also highlighted the need to reconsider the relevant indications.

Indications for ESC at the 1998 consensus agreement in Belgium in 1998 are as follows:

- Complete nasal obstruction due to cystic fibrosis-related massive polyposis and excessive medialization of the lateral nasal wall
- Antrochoanal polyps
- Intracranial complications of sinus diseases
- Mucocele and mucopyocele
- Orbital abscess
- Traumatic injury of the optic canal
- Dacryocystorhinitis secondary to sinusitis
- Fungal sinusitis
- Some meningoencephaloceles
- Some skull base tumors, such as angiofibroma
- Chronic sinusitis resistant to medical treatment

68.2 Antrochoanal Polyp

Antrochoanal polyp is a usually unilateral benign polypoid formation generally deriving from the maxillary sinus and rarely from the sphenoid and ethmoid sinuses. Edematous sinus mucosa extends from the sinus ostium to the nasal cavity and from there to the nasopharynx. Antrochoanal polyps represent 1/3 of nasal polyps in children. Histologically, the inflammatory and eosinophil cells seen in inflammatory polyps are not observed in antrochoanal polyps [1–3]. Surgery is the treatment of choice. Removal of the choanal part of the polyp alone leads to high recurrence rates. The Caldwell-Luc operation was used to be performed to remove the cystic antral portion. This is not popular today due to the possibility of damage to the maxillary growth centers and dental stem cells during the opening of the bone window during the surgery. Nowadays, the method of choice is endoscopic sinus surgery. Following uncinectomy, the site of exit of the polyp from the maxillary sinus is determined. Antrochoanal polyps may extend from the natural ostium or from the accessory ostium into the nasal cavity [4, 5]. If the polyp extends from the ostium into the nasal cavity, combining the ostium and the accessory ostium and performing a wide middle meatal antrostomy facilitates the excision of the antral and choanal portion in a single segment. Complete excision of the antral portion reduces recurrence. Care must be taken to ensure that the maxillary sinus mucosa are completely cleared by using degree telescopes and equipment and sometimes motorized instruments [6, 7] (Figs. 68.1, 68.2, and 68.3).

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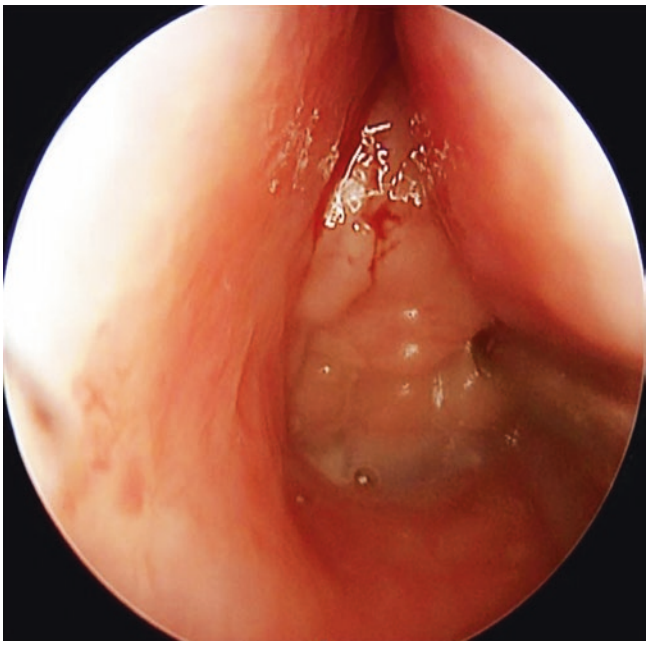

Fig. 68.1 Posterior choana totally obstructed by adenoid tissue. Accumulation of nasal secretion due to obstruction can be seen

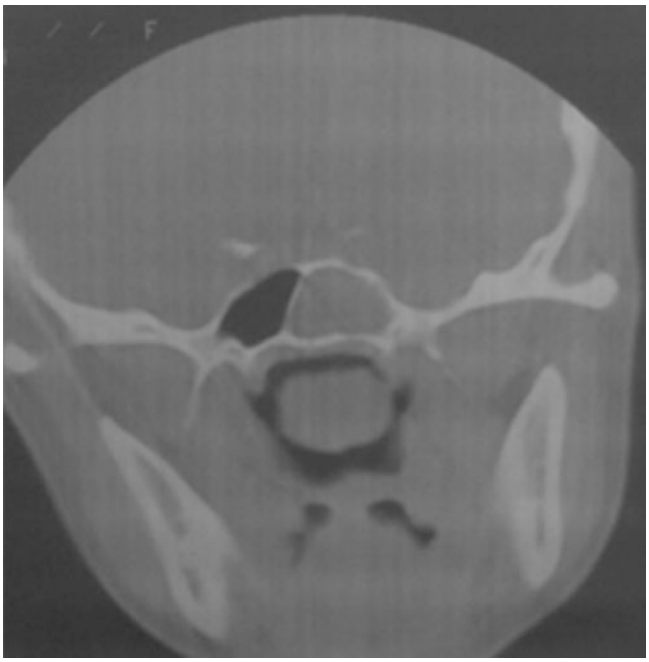

Fig. 68.3 Sphenochoanal polyp extending to nasopharynx seen in paranasal sinus CT coronal scan

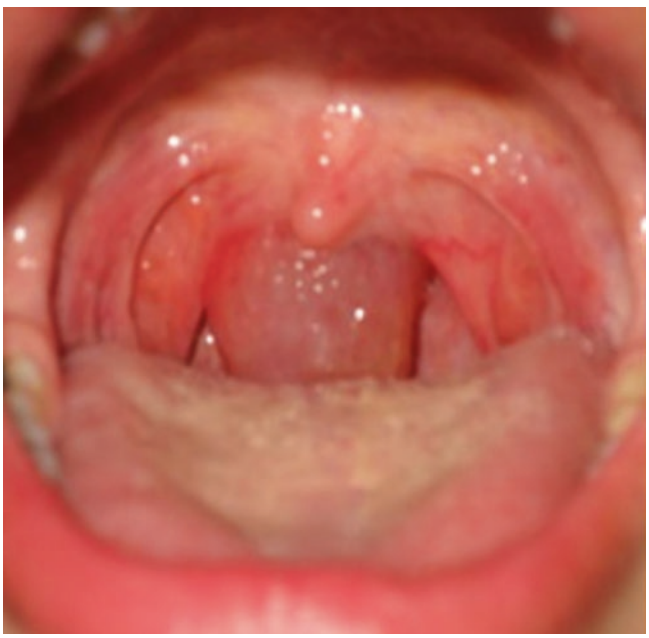

Fig. 68.2 Sphenochoanal polyp seen from oropharynx

68.3 Fungal Sinusitis

There are invasive and noninvasive types. The invasive type is generally seen in children with compromised immune system, such as lymphoma or leukemia. The disease is rare, but can be fatal. Studies have reported a mean mortality rate of 66%, ranging between 33% and 100% [8]. *Alternaria* and *Aspergillus* are the most commonly isolated fungi. Aggressive medical treatment based on wide surgical debridement and biopsy results is lifesaving in patients with immune system disorders. Amphotericin B and lipid forms of amphotericin are the main drugs used in medical treatment. Other antifungals, such as itraconazole and voriconazole, can also be added to treatment [9, 10].

The noninvasive type is divided into two forms, fungus ball and allergic fungal sinusitis. The condition may proceed with severe sinus disease. It occurs with the paranasal sinus mucosa developing hypersensitivity to fungi. Fungi that cause allergic fungal sinusitis include *Aspergillus*, *Alternaria*, *Bipolaris*, and *Curvularia*. It may cause facial shape impairment and proptosis in children due to dilation of the sinuses. Double density and complete opacity generally involving a single sinus may be determined through computerized tomography (CT scan) [11]. Surgical treatment involves debridement of the fungi filling the sinus and removal of the allergic mucin from inside the sinus [9] (Figs. 68.4, 68.5 and 68.6).

68.4 Mucocele and Mucopyocele

Mucoceles are epithelium-lined sacs completely covering one or more paranasal sinuses. They are rare in children, and the underlying pathology is frequently cystic fibrosis [12]. Frequent infection, allergy or other agents blocking the sinus ostium such as trauma may also lead to mucocele. They may turn into mucopyocele if the mucus is infected. The course is expansile.

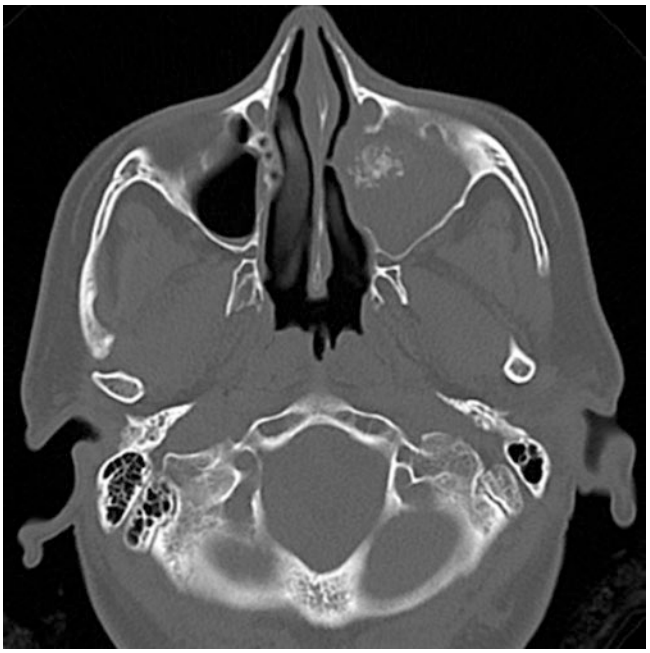

Fig. 68.4 Fungus ball totally obliterates maxillary sinus. Axial scan bone window

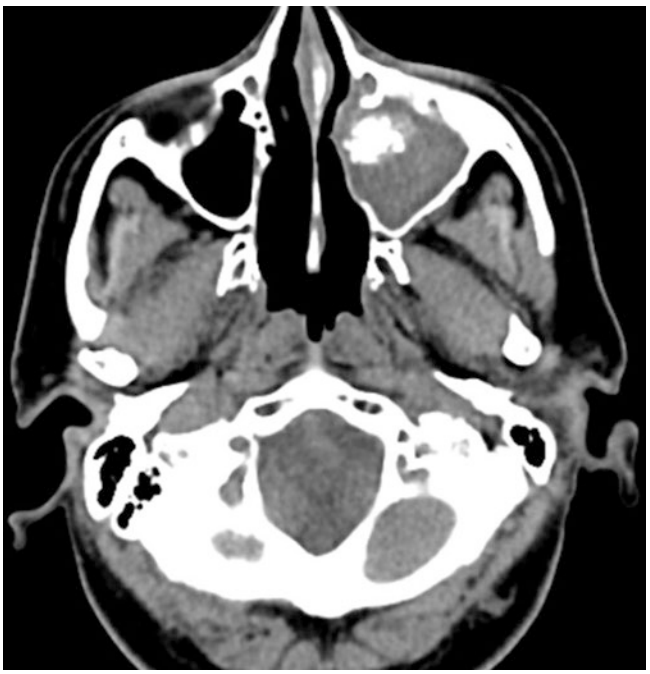

Fig. 68.5 Different densities in maxillary sinus seen in fungus ball. Axial scan soft tissue window

Indeed, the initial finding in children may be a painless swelling in the cheek. They may lead to intracranial or intraorbital complications causing bone erosion. Although total excision with the entire epithelium was performed in the past, today's treatment is drainage of the mucocele with wide anastomosis of the nasal cavity using an endoscopic approach [13, 14].

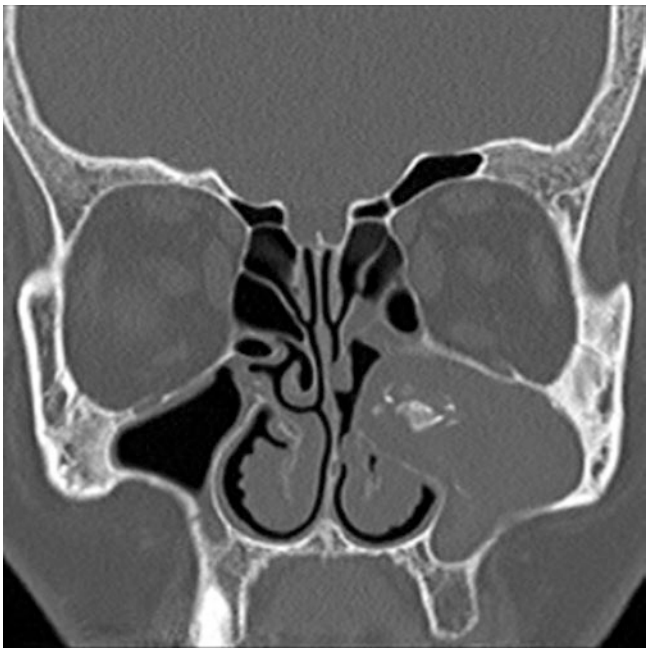

Fig. 68.6 Fungus ball causing medial replacement of maxillary sinus medial wall. Coronal scan bone window

68.5 Cystic Fibrosis, Ciliary Dyskinesia, Immune Deficiency

Pediatric patients with poor response to medical treatment and with frequent relapses must be carefully examined. Low IgG subgroups and IgA levels, a decrease in ciliary movements, or various endocrine disorders can be identified through detailed system examinations and laboratory findings.

Primary ciliary dyskinesia is an autosomal recessive disease with a prevalence of 1/15,000 that proceeds with chronic cough, phlegm, asthma, and bronchiectasis. Definitive diagnosis is made by examination of biopsies taken from mucosa under electron microscopy. Kartagener syndrome, with findings of bronchiectasis, chronic rhinosinusitis, and *situs inversus*, is found in 50% of patients.

Cystic fibrosis is an autosomal recessively transmitted disease. Thickening of secretions in the exocrine glands due to mutation in the CFTR gene and characterized by findings such as nasal polyp, chronic rhinosinusitis, bronchiectasis, and pancreatic insufficiency. The medial maxillary wall pressing toward the nasal cavity may lead to nasal obstruction.

ESC has also been shown to be useful in patients with cystic fibrosis and ciliary dyskinesia. The goal in these patients is to increase the effectiveness of topical antibiotics and irrigation through wide medial maxillary antrostomy. Removal of the maxillary wall exerting pressure in a medial direction reduces nasal obstruction in patient

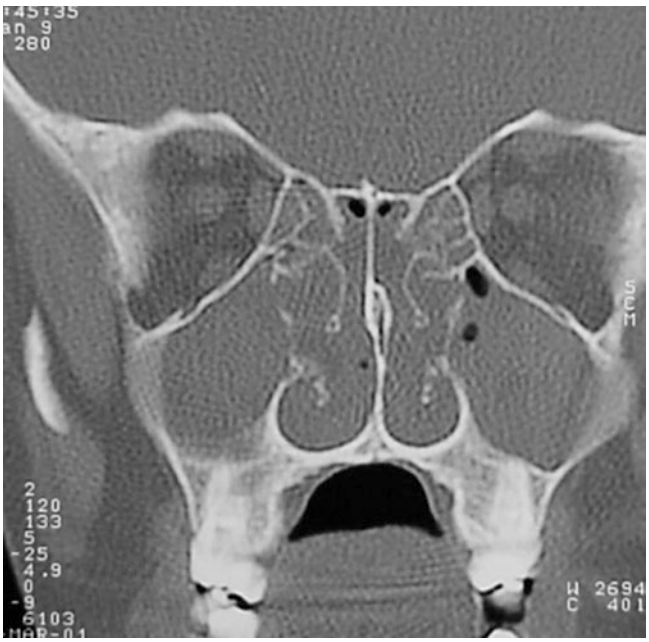

Fig. 68.7 Kartagener syndrome; all of the sinuses totally obliterated. Paranasal sinus CT

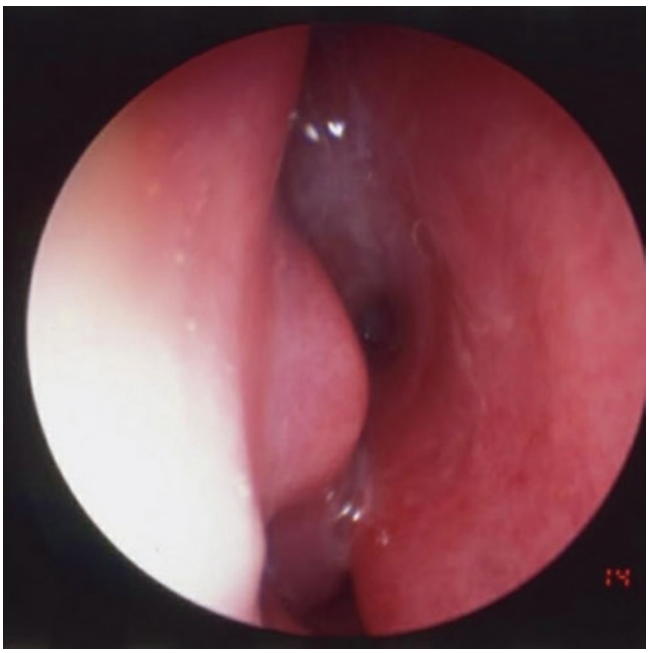

Fig. 68.9 Kartagener syndrome, endoscopic view after medical treatment shows little improvement

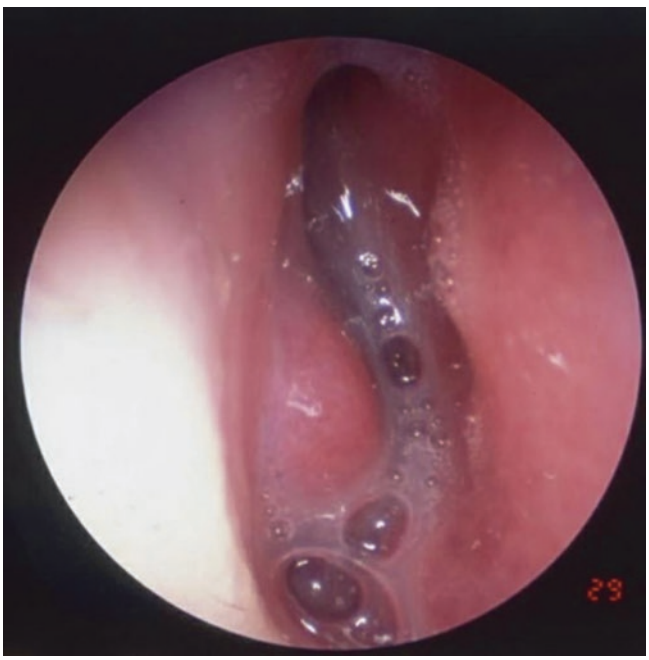

Fig. 68.8 Kartagener syndrome, endoscopic view before medical treatment

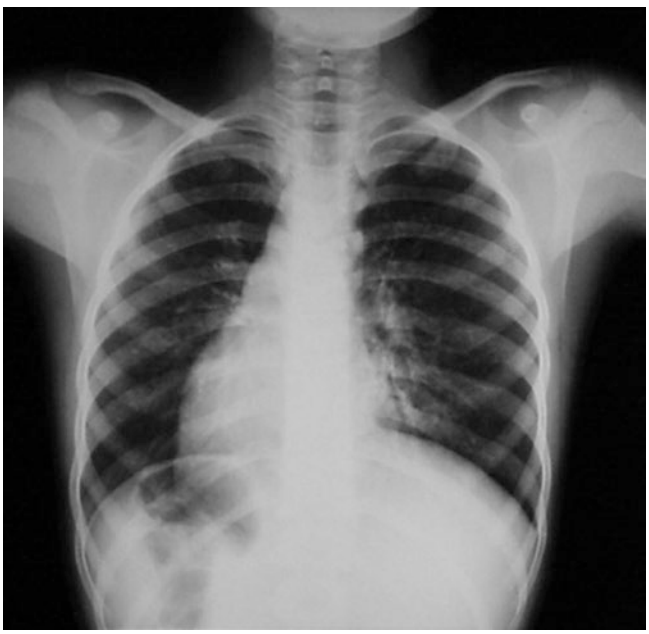

Fig. 68.10 Situs inversus, Kartagener syndrome

with cystic fibrosis. Even if an improvement in pulmonary functions is not established after ESC, it nevertheless reduces the requirement for intravenous antibiotic therapy, and improves quality of life [12, 15] (Figs. 68.7, 68.8, 68.9, and 68.10).

68.6 Surgical Treatment in Chronic Rhinosinusitis (CRS)

Indication for surgery may be shown with relatively easier diagnoses such as antrochoanal polyp, mucocele, mucopyocele, fungal sinusitis, cystic fibrosis, and immotile cilia.

However, still there is no consensus in favor of surgery in CRS resistant to medical treatment or on the limits of the surgery to be performed [16, 17].

The next step in patients who have received long-term medical treatment and with normal allergic and immunological scans must be CT of the paranasal sinus. These patients may be candidates for appropriate ESC in the presence of anatomical variation that impairs sinus ventilation and drainage at CT (such as lateralized uncinate process, concha bullosa, Haller cells, septal deviation, septal spur, or choanal atresia) [18, 19].

If no anatomical variation is identified, before performing ESC, antibiotherapy and adenoidectomy with culture from inside the sinus is the next treatment step, particularly in children aged under 6 [20–23].

In a study by Bhattacharyya in 2006, the mean Lund-MacKay score of children scheduled for ESC due to cystic fibrosis with anatomical variation was 10.4, compared to a mean score of 2.4 in children undergoing CT for nonsinusitis. CRS may be considered in the presence of a CT score of 5 or over and of clinical findings [24].

Timing of the operation is very important in the success of CRS surgery. In a study by Ramadan in 2003, a significant difference was determined between surgical success in children aged under 6 and those aged over 6, in favor of the latter. In the 1980s, when ESC began being performed, there was a debate over whether or not this procedure would have an adverse impact on development of the sinus and facial growth in children. In later years, however, experimental, retrospective, and prospective studies showed that ESC has no adverse effects on facial and sinus development [25–27].

ESC in children differs from that in adults. Frequent upper respiratory tract infections cause mucosal edema. In addition, the narrowness of the surgical field makes endoscopic procedures more difficult. The thinness of the bone lamellae surrounding the nose needs much greater care. Although there is no fundamental difference between adult and pediatric ESC, for these mentioned reasons, the procedure being performed by an experienced surgeon helps reduce potential complications. Children's poor compliance at postoperative check-ups also reduces the success of ESC in childhood [28, 29].

Since the sinus is still developing in childhood, the procedures performed are generally more limited. Clearing the ethmoid bulla and the ostium of the maxillary sinus with uncinectomy is usually enough. Even if mucosal inflammations persist in the early postoperative period in these children, these inflammations have been shown to disappear after 1–2 years [30, 31].

Care must be taken to be minimally invasive, particularly in children under 10. Wider surgery can be performed if indicated in children over 10.

68.7 Choanal Atresia Surgery

Choanal atresia may be described as a nasopharyngeal opening defect of the posterior choanal of the nasal cavity. It is a rare disease seen in 1:5000–7000 births. Bony structures compromising the base of the sphenoid sinus constituting the posterior choanal in the superior part, the horizontal portion of the palatal bone in the inferior, the vomer in the medial, and the medial pterygoid lamina in the lateral part cause narrowing and represent the objective in surgical planning.

The disease is characteristically unilateral-bilateral, with a female-male, and right-left ratio of 2:1 [32, 33].

Other congenital anomalies have been detected in 51% of patients with choanal atresia [34].

Unilateral choanal atresia may not present to physicians until a more advanced age. Patients may present with unilateral seromucoid nasal discharge, and frequently with sinusitis bout. The possibility of surgery at a more advanced age increases the probability of postoperative success.

Bilateral choanal atresia presents with severe respiratory stress due to the newborn being unable to breathe through the mouth. Increased cyanosis during suckling but improving with crying is typical. Special airways, tracheal intubation or tracheostomy, may be planned to treat respiratory distress in these patients [35].

Methods such as an N/G tube being unable to be inserted into the oropharynx by the nasal route and observation of the oropharynx by dropping methylene blue into the nasal cavity are used in diagnosis, although nasal endoscopic examination with fiber-optic or rigid telescopes is commonly employed today. Thin-slice paranasal sinus tomography plays an important role in confirming diagnosis and in identifying which bone is responsible for obstruction and in planning treatment.

Surgical treatment of choanal atresia has been performed using various methods since the mid-nineteenth century. The choana used to be opened by piercing with a hard probe by the transnasal route, and choanal opening was later achieved by accessing the atretic plate by the transpalatal route and shaving the tissue from there. Today, thanks to the development of telescopes and motorized devices, this procedure is now performed transnasally using endoscopy. Once the mucosa on the atretic plate has been removed, the nasopharynx is reached from the thinnest point, as shown by preoperative CT. This point is generally where the vomer and the hard plate intersect. Care must be taken when working with a tissue shaver to remain below the tail of the middle concha. Once the nasopharynx has been identified, the atretic plate is shaved toward the superior and inferior of the lateral aspect. The vomer is excised from the posteroinferior direction to ensure that the newly formed choana is single and permanent. No more than 1/3 of the vomer must be removed in order not to affect the nasal septum growth centers. In order

to reduce postoperative restenosis, care must be taken not to leave sharp bone edge and not covered with mucosa. The subject of postoperative stent use and how long the stent should be kept in place if used is controversial. Reports that stent causes postoperative discomfort and more recently that stent use does not reduce the probability of restenosis have led to a decrease in its use. Nasal irrigation in the postoperative period is important to prevent restenosis. Although mitomycin C is sometimes used in the postoperative period, it has failed to gain popularity since there is no significant difference in terms of reducing restenosis and also due to its potential carcinogenic effect [33, 35].

68.8 Meningoencephalocele and Endoscopic Rhinorrhea Repair in Children

With the endoscopy approach, important changes took place in the surgical treatment of meningoencephalocele. Such lesions were previously approached with bicoronal incision frontal craniotomy. However, this technique caused severe complications, such as intracranial bleeding, epilepsy, and anosmia. When these lesions started being repaired via the nasal route, these complications became more rarely.

As with other pediatric endoscopic procedures, the narrowness of the surgical field and concerns over facial sinus development mean that very great care and specialized equipment are needed in meningoencephalocele surgery [30, 36]. There is no consensus on the use of septal cartilage and various nasal mucosal flaps as we use in adults.

Since meningoencephaloceles are generally lined with mucosa, they are hard to detect. The first findings may be nasal obstruction, nasal discharge, and meningitis bouts in later in life. Diagnosis is made with paranasal CT and magnetic resonance imaging (MRI). Careful investigation of whether the sac inside the nasal cavity contains vital tissues such as the cranial nerve, pituitary gland, or blood vessels is essential, and surgery must be planned accordingly. Because those lesions are asymptomatic at birth, surgery could be delayed looking for a wide surgical area and adverse impact on development of the sinus and face [25]. However, the child findings must be primarily considered in planning the timing of surgery. Technically, surgery is the same as that in adults. Multilayer closure is recommended in order to prevent postoperative CSF leakage. Just as with adults, it is important to free the bone in the area of the defect from mucosa in order to completely expose the defect in the skull base. Part of the middle concha or septum may be taken due to narrowness of the surgical field or the anatomical location of the sac. The bone, mucosa, and submucosa of the resected concha could be used during the closure of defect [37]. Materials such as gelfoam, surgicel, or the Foley catheter can be used for stabilization of the grafts employed. The fact that tampons are absorbable makes them preferable in the postoperative period due to the difficulty of performing dressings for children. Following the repair of large defects, epithelialization can be initiated if necessary, and the child can be kept under general anesthesia for up to 2 days. It is essential for the neurosurgeon, anesthesiologist, and pediatricians to work as a multidisciplinary group in order to overcome such difficulties [38].

68.9 Pediatric Sinusitis Orbital Complications and Treatment

Sinusitis-related orbital complications are more common in children than in adults. Delays in diagnosing and treating orbital complications can result in visual losses and even fatal complications such as brain abscess. The ethmoid sinus, the most developed sinus in children, is usually the source of the infection. Orbital complications are divided into four classes: preseptal cellulitis, orbital cellulitis, subperiosteal abscess, and orbital abscess. According to some classifications, the presence of abscess and whether it is subperiosteal or orbital is more important than the site of the infection in planning treatment [39].

Patients generally present with findings such as edema in the eyelid, reddening in the eye, restricted movement in the eye, and visual impairment. It is very important for intravenous antibiotic therapy to be initiated since the beginning of the treatment. CT is very important for the decision to operate and for identifying the site of the infection or abscess. CT must be performed with high-risk patients for protection against the deleterious effects of radiation on children. Ocular examination is very important for identifying these patients. Eye examinations must be performed at 2–3-h intervals, and CT must be requested for patients with impaired vision or increasing restriction in eye movements. CT must also be performed on patients not responding to antibiotic therapy within 24–48 h [40].

Exposure of the lamina papyracea with anterior ethmoidectomy and allowing the abscess to drain by lifting the lamina papyracea is generally sufficient to drain the abscess. Although most abscesses can be accessed by this route, endoscopic and external approaches may need to be combined for complete draining of abscesses extending toward the superior and lateral directions at CT [41].

68.10 Endoscopic Tumor Surgery in Children

The principles of endoscopic tumor surgery in children are similar to those in adults. However, angiofibroma surgery in the pediatric age group has its own distinct characteristics. Angiofibroma is a rare disease representing 0.5% of tumors

in the head and neck region. It is an expansile tumor deriving from around the sphenopalatine foramen and extending toward the orbita and even the intracranial region by causing bone erosion in the pterygomaxillary fossa and infratemporal fossa [42]. Angiofibroma surgery has always been difficult due to the anatomical area from which it derives and the dense blood supply. Open surgery by the transnasal or transoral routes used to be preferred, but thanks to advances in endoscopic equipment and devices, improvements in embolization techniques, and increasing experience on the part of endoscopic surgeons, endoscopic excision is more popular today.

Classifications are based on the size of the tumor and the anatomical areas involved. Although the Radkowski classification is the most commonly used, it is insufficient for determining appropriate candidates for endoscopic excision [43]. The Önerci classification is a new technique that assists with the identification of suitable patients for endoscopic excision. Previously, endoscopy was only used to attempt to resect small tumors restricted to the nasal cavity, but today even masses with intracranial spread can be resected using endoscopy [44].

In the endoscopic method, following anterior posterior ethmoidectomy, expanded procedures can be performed depending on the extent of the tumor, including wide medial antrostomy, opening the posterior wall of the maxillary sinus, opening the anterior wall of the sphenoid sinus, and resection of the posterior part of the nasal septum. Although past studies reported no decrease in bleeding levels with embolization, with advances in new embolization techniques, more recent research has reported less bleeding in patients undergoing embolization. The blood supply to the tumor is basically from the maxillary branch of the ipsilateral external carotid artery. There may also be collaterals from the ipsilateral internal carotid and contralateral external carotid branches. Identifying and clipping the sphenopalatine artery and even the internal maxillary artery will reduce the level of bleeding during surgery to a significant extent. Once the tumor has been free from the lateral and superior aspects, it can be removed via the nasal route by being carried toward the nasopharynx, or by the oral route in the case of very large tumors. In the postoperative period, absorbable tampons such as Spongjel or Surgicel are enough to complete hemostasis. Nasal irrigation is very important in order to prevent crusting. If necessary, decrusting can be performed under mild sedation or general anesthesia in noncompliant patients [45].

Endoscopic sinus surgery has been safely performed on children since the 1980s. Although it used to be thought it would have a deleterious impact on sinus and facial development, this has been shown to be incorrect. In addition, it offers unquestionable advantages, such as the elimination of the need for facial incisions and osteotomies, particularly in some tumor surgeries, very little bleeding during surgery and easy identification and protection of important anatomical areas. Thanks to advances in endoscopic devices and equipment and in embolization techniques, surgery is possible inside the nose and even extending the margins in the intracranial region [31].

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