Medical Science

Empty Nose Syndrome: A review of pathogenic mechanisms, diagnostic strategies, and patient-centered treatments

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ABSTRACT

Empty Nose Syndrome (ENS) is a rare but complex condition that can arise after nasal surgeries, like turbinate reduction. Even though the surgery is usually intended to improve nasal function, patients with Empty Nose Syndrome (ENS) often continue to have problems such as nasal obstruction, dryness, and a paradoxical feeling of suffocation. This review explores the causes, diagnosis, and treatment of ENS, emphasizing the aspects that are most important to patients. We explore the interplay between structural changes in the nose and various sensory and neurological factors contributing to the distressing symptoms of Empty Nose Syndrome (ENS). This review explores various treatment options for managing Empty Nose Syndrome (ENS). Non-surgical methods, such as nasal moisturizers and psychological support, have been shown to effectively alleviate symptoms occuring with this condition. In contrast, surgical interventions like submucosal turbinoplasty and radiofrequency surgery are used to restore nasal function and improve the overall quality of life for patients. Using a personalized, patient-centered care approach is essential for effectively managing treatments for conditions such as Empty Nose Syndrome (ENS). Successfully addressing both the physical symptoms and emotional problems in ENS patients requires coordinated collaboration among different medical specialties. Additionally, it is essential to establish standardized diagnostic criteria and develop innovative treatments that meet the diverse needs of individuals affected by ENS.

Keywords: Empty Nose Syndrome (ENS), Pathogenic Mechanisms, Nasal Physiology, Diagnostic Strategies, Patient-Centered Treatments, ENS Symptoms, Turbinate Dysfunction, Surgical Interventions, Quality of Life, Management of ENS

1. INTRODUCTION

The clinical phenomenon known as empty nose syndrome (ENS), first identified by Moore and Kern, (2001), is contentious, with some writers questioning its existence. There is no agreed-upon definition for it. It occurs in certain people following sinus or nasal surgery, especially after inferior turbinectomy, but it is uncommon even in these cases. There may be neuropsychological involvement. The most prevalent manifestation is paradoxical nasal obstruction; however, the symptomatology is flexible and fluctuating (Coste et al., 2012; Moore and Kern, 2001; Chhabra and Houser, 2009). It links the loss of standard endonasal structure, namely the lack of one or more turbinates, to the symptoms of atrophic rhinitis (Payne, 2009).

Following inferior and/or medial turbinate surgery, ENS is a known complication that may appear months or years later (Houser, 2007). It should be differentiated from atrophic rhinitis (also known as ozena), a fundamental disorder of uncertain origin affecting the sinonasal tissues that exhibit similar symptoms. The most prevalent symptom is "paradoxical" nasal obstruction, which patients experience even if the clinical examination shows objectively permeable cavities while imaging, rhinomanometry, and acoustic rhinometry show no blockage (Houser, 2007; Passali et al., 2021).

Although the precise prevalence of ENS is unknown, many studies have shown an occurrence rate of 8% to 22% in individuals who have had turbinate resection (Freund et al., 2011). If done too aggressively, submucosal cautery, submucosal excision, laser treatment, and cryosurgery can potentially form ENS (Naftali et al., 2005). Due to the incomplete understanding of ENS pathophysiology, current diagnostic and therapy approaches have limitations.

2. MATERIALS AND METHODS

A systematic approach was employed to identify studies relevant to Empty Nose Syndrome (ENS) and its interplay with pathogenic mechanisms, diagnostic strategies, and treatment options. Keywords and Boolean operators were carefully selected to refine the search process. Some examples of search strings used in PubMed include: "Empty Nose Syndrome" OR "ENS" AND "pathophysiology" OR "mechanisms", "Nasal obstruction" OR "turbinate dysfunction" AND "ENS diagnosis", ENS treatment" OR "surgical management" AND "non-surgical approaches", "Nasal airflow" AND "quality of life" OR "patient outcomes".

Similar terms and filters were applied on Google Scholar to locate grey literature that might provide additional insights or perspectives. Relevant articles were identified based on their focus on ENS-related pathogenic mechanisms, diagnostic tools, and therapeutic interventions. The review prioritized peer-reviewed articles, systematic reviews, and meta-analyses to include only high-quality research.

3. RESULTS AND DISCUSSION

The lower, middle, and upper turbinates are parts of nasal physiology, providing heating and moisturizing the inspired air. Their preservation is crucial and should always be considered. When irreversible hypertrophy of the turbinates disturbs nasal physiology, particularly ventilatory function, the intervention that must be used must be the most conservative approach that respects the mucosa among the dozens of methods proposed in the literature. A patient with Empty Nose Syndrome (ENS) may be considered for surgery when conservative treatments, such as nasal saline, humidifiers, and pharmacological interventions fail to help with symptoms and significantly impact their quality of life. Indications for surgery include persistent nasal dryness, difficulty breathing, and a sense of suffocation despite regular or overly open nasal passages.

For example, when structural abnormalities (such as excessive turbinate reduction or mucosal atrophy) are identified, surgical intervention may be necessary. Considering the patient's overall health, symptom severity, and psychological state is very important, with a multidisciplinary approach to ensure the best outcomes. Because clinical and anatomical images might differ significantly, a shared scientific vocabulary must be established for performing statistics and comparisons. Therefore, given the various clinical images, it would seem acceptable to suggest an ENS classification that may generally distinguish across post-surgical circumstances (Passali et al., 2021). Key points of the review work are summarized in (Table 1).

Table 1 Key points

Aspect	Findings	Implications
Pathogenic Mechanisms	ENS results from reduced mucosal area, diminished airflow resistance, loss of thermoreceptors (TRPM8), and impaired nasal function (humidification, airflow control).	Highlights the necessity of preserving mucosal tissue and nasal structures during surgery to ensure proper airflow.
Diagnosis	ENS diagnosis relies on subjective assessments (e.g., ENS6Q, SNOT-20), endoscopic evaluation, and imaging (CT/MRI). Cotton test confirms symptom improvement.	Highlights the need for standardized diagnostic criteria and use of multidisciplinary approaches for accurate identification of ENS.
Conservative Treatments	Nasal moisturizers, humidifiers, saline irrigation, and psychological support show symptom relief in some patients.	Non-surgical approaches should be prioritized as first-line interventions to improve quality of life while avoiding further complications.
Surgical Treatments	Techniques like submucosal turbinoplasty, implants, and cartilage grafting aim to restore nasal function and volume.	Surgical interventions are helpful but require careful patient selection, multidisciplinary planning and psychological support.
Patient-Centered Care	ENS significantly impacts emotional health, often leading to anxiety, depression, or reduced quality of life.	Calls for personalized treatment plans combining medical, surgical, and psychological interventions to address both physical and mental health outcomes.
Future Directions	Limited understanding of ENS pathophysiology and outcomes of current treatments.	Advocates for more research on ENS mechanisms, development of innovative diagnostic tools, and long-term evaluation of treatment outcomes.

Pathogenic Mechanisms

Although the physiopathology of ENS is still poorly understood, the literature provides several complementary theories. It may be attributed to a reduction in mucosal area Freund et al., (2011), which results in a loss of physiological nasal functions (warming, humidification, and air purification) and a corresponding loss of the tactile, thermal, and sensory receptors Naftali et al., (2005) required for inhaled air treatment. Scheithauer, (2010) showed that ENS was linked to reduced nasal airflow resistance, increased warmth, and decreased humidification (Freund et al., 2011; Mertz et al., 2000). Several studies have clearly shown that a significantly reduced inferior turbinate volume alters the nasal cavity outflow regime, boosting and speeding up the flow in the inferior (Payne, 2009; Ren and Dubner, 2002).

These modifications cause a change in pulmonary function. Nasal resistance is crucial to maximize alveolar ventilation and open peripheral bronchioles. Consequently, this boosts cardiac and pulmonary venous return, raises negative thoracic pressure, and improves gas exchange (Houser, 2007). As a result, proper nasal resistance to expiration maintains lung volume, which indirectly controls arterial oxygenation (Gracely et al., 2002). Adequate cooling of the mucosa and a sufficient amount of functional TRPM8 (transient receptor potential cation channel subfamily M member 8) thermoreceptors are necessary for nasal patency (Jang et al., 2011). Turbinate resection in ENS reduces the overall nasal surface area, which alters the properties of laminar airflow.

Because of the larger nasal cavity, less air-mucosa contact, and decreased nasal airway resistance, the loss of mucosa results in fewer TRPM8 receptors as well as a violation of inspired air heating and humidification (Freund et al., 2011). A 23% reduction in humidity and warmth can be achieved by obliterating the inferior turbinate (Piccirillo et al., 2002). As a result, the mucosa heats up more as a compensatory strategy. Because TRPM8 is not activated and adequate mucosal cooling does not occur, there is limited communication to the respiratory center, which is mistaken for blockage or apnea and ultimately results in higher breathing attempts.

It is significant to remember that inferior turbinate resection carries a more considerable risk of developing ENS than middle turbinate removal. To limit the incidence of ENS, it is advised that at least 50% of the inferior turbinate be preserved during any surgical treatment that permits the preservation of adequate mucosa and maintains the modest nasal volume necessary for proper airflow (Berenholz et al., 1998). Significant compensatory structural changes brought on by the reduction of mucosal tissue following surgery cause ENS patients to have fewer submucosal glands, a greater incidence of submucosal fibrosis, goblet cell metaplasia, and squamous metaplasia. Nonetheless, inflammation can be avoided in certain instances, and the typical respiratory epithelium resembling atrophic rhinitis can be maintained (Thamboo et al., 2017).

The alterations induce the sensation of obstruction reported by patients, which may go as far as a feeling of suffocation. The sensation of pharyngeal dryness is sometimes reported due to the air flow insufficiently humidified by the nasal mucosa and drying of the rhinopharyngeal mucosa (Scheithauer, 2010). Central involvement is currently under study. The paradox could be due to alterations in nasal permeability or the valence of neural efferents from the nasal mucosa (Freund et al., 2011). The pathophysiology of ENS is complex and includes abnormalities in the anatomy of the turbinate, disturbances in the normal function of the nasal mucosa, and a lack of neural feeling.

Impact of turbinectomy on the onset of ENS

Late consequences of turbinectomy include ENS and atrophic rhinitis. ENS has been documented as a consequence of partial resection, primarily involving the inferior turbinectomy of the anterior part or head of the turbinate, which is crucial for internal valve function. However, the most significant risk is associated with large-scale resection (total or subtotal turbinectomy) (Amin and Koufman, 2001). Therefore, following a formal indication (nasal blockage that is not responsive to appropriate medical treatment in individuals with turbinal hypertrophy), conservative surgery (turbinoplasty, radiofrequency surgery, etc.) is advised. It is now impossible to anticipate the risk of ENS, and the amount of mucosa removed is not always linked to it.

Different ENS subtypes are distinguished by whether they are secondary to inferior turbinectomy (ENS-IT), medial turbinectomy (ENS-MT), or both (ENS-both) (Amin and Koufman, 2001). The most common is ENS-IT. Paradoxical nasal blockage and very dry mucosa are the main complaints. One explanation for this common blockage after inferior turbinectomy is its function in regulating nasal airflow. ENS-MT is less common. In addition to the usual nasal blockage, it causes respiratory pain, which may be brought on by the pterygopalatine ganglion's lack of mucosal protection (Amin and Koufman, 2001). For a long time, ENS was linked to an iatrogenic form of atrophic rhinitis. However, several writers described a difference between the two (Chhabra and Houser, 2009; Amin and Koufman, 2001).

They were puzzled due to the contradictory sensations of blockage, dryness, and crusts present in both. It ranges from 2 to 20% depending on the type of turbinal surgery, and the risk of developing atrophic rhinitis after surgery that involves mucosal resection is caused by both unknown individual and environmental factors in addition to the amount of mucosa removed (Thune et al., 2021). There is a debate on the existence of any such organic pathology because ENS only affects a small percentage of individuals who have had one or more endonasal surgeries.

Only a portion of the underlying causes are known. The frequent correlation between mental illnesses and potentially psychosomatic conditions (fibromyalgia, functional colopathy, etc.) is one area of disagreement (Payne, 2009; Freund et al., 2011; Gill et al., 2019; Bhandarkar and Smith, 2010; Huang et al., 2021). It has been claimed that psychological stress may play a part in tinnitus in certain people. In the specific situation of neuropathic individuals, a neurological component may potentially play a role in the onset (Modrzyński, 2011).

Diagnosis

Collaboration between otolaryngologists, radiologists, and psychologists is essential for a holistic and patient-centered approach to ENS care. The range of symptoms, the lack of a widely accepted clinical description, and the accompanying psychological and occasionally social discomfort make diagnosing ENS more challenging. Subjectively reported symptoms and a clinical examination based on a nasal cavity endoscopy conducted during consultation serve as the basis for the clinical diagnosis. A feeling of nasal blockage is the hallmark presenting symptom and is occasionally accompanied by feelings of suffocation, dyspnea, or difficulty breathing.

Additional symptoms, including soreness, a sense of having an empty nose, or dryness in the rhinopharynx, are also frequently observed. The severity of the symptoms varies and might limit daily activities (Moore and Kern, 2001). Individuals with ENS symptoms may experience despair, anxiety, irritability, exhaustion, or loss of attention (nasal aprosexia) (Chhabra and Houser, 2009; Payne, 2009; Freund et al., 2011; Amin and Koufman, 2001). Additional commonly reported symptoms include: headache; nasal and pharyngeal dryness; hypersensitivity to cold air; dyspnea (also paradoxical), dyspnea, dyspnea, and hyperventilation; sensation of excessive airflow; lack of sensation of nasal airflow; difficulty falling asleep, and general fatigue (Chhabra and Houser, 2009; Payne, 2009; Malik et al., 2019; Li et al., 2018).

Questionnaires

The Sino-Nasal Outcome Test (SNOT) is a valuable tool for assessing symptoms and quality of life in patients with Empty Nose Syndrome (ENS). Though initially designed to evaluate a wide range of sinonasal conditions, SNOT questionnaires (e.g., SNOT-20, SNOT-25) are particularly useful in ENS to quantify the severity of symptoms such as nasal dryness, difficulty breathing, and reduced airflow sensation. Patients rate symptoms on a scale, providing subjective insights and measurable data for tracking progress. These questionnaires also capture the emotional impact of ENS, such as depression or anxiety, offering a holistic view of the condition. While not diagnostic on their own, SNOT scores complement other tools like the ENS6Q, nasal endoscopy, and imaging in the comprehensive evaluation of ENS (Payne, 2009; Rice, 2000).

Physical examination

Physical examination is crucial in evaluating Empty Nose Syndrome (ENS). During a thorough assessment, the clinician focuses on structural and functional changes in the nasal cavity that may contribute to symptoms (4). Key components include:

Nasal endoscopy is the cornerstone of physical examination in Empty Nose Syndrome (ENS). It allows direct visualization of the nasal cavity to identify key abnormalities, such as over-reduction or absence of nasal turbinates, excessive nasal patency (wide-open spaces), dryness, crusting, or atrophy of the nasal mucosa.

External Nasal Examination: Inspection of the nose's external structure ensures no visible deformities or abnormalities in nasal airflow dynamics.

Airflow Testing (Cotton Test): The cotton test involves placing small cotton pieces in the nasal cavity to emulate the function of turbinates. Improvement in symptoms during this test strongly suggests ENS and confirms the role of structural changes in the condition.

Mucosal Assessment: The physician checks the nasal mucosa for signs of dryness, reduced secretions or irritation, which are symptoms of Empty Nose Syndrome (ENS).

Imaging plays a crucial role in assessing ENS, offering detailed insights into structural changes that may not be visible during a physical examination. CT scans provide high-resolution images of the nasal cavity and sinuses. They can reveal excessive turbinate reduction, widened nasal airways, and loss of mucosal surface area, which are hallmark findings in ENS. MRI can also assess soft tissue structures and mucosal integrity, particularly when inflammation or scarring is suspected. CFD is emerging as a valuable tool, allowing clinicians to analyze airflow patterns and areas of disrupted nasal function. These imaging modalities are critical in diagnosing ENS, guiding treatment decisions, and monitoring outcomes.

In almost 50% of patients, sinus CT reveals maxillary opacity and rhinosinus mucosal thickening (Thune et al., 2021; Li et al., 2018; Cook et al., 1995). Rhinomanometry is a test that measures nasal airflow and resistance, providing objective data about functionality of the nose. In cases of empty nose syndrome (ENS), the results often show normal or reduced resistance, even when the patient experiences a sensation of obstruction. This describes the paradoxical nature of the condition. Rhinomanometry serves as a valuable complement to subjective assessments during the diagnostic process (Houser, 2007; Freund et al., 2011). Cotton testing is perhaps the most effective clinical method for diagnosing ENS patients (Fischer et al., 2000).

To re-establish the bulk of turbinate-associated tissue, a dry cotton plug is inserted into the area of the inferior meatus and inferior lateral nasal wall. Surprisingly, a lot of ENS patients say that their nasal breathing has improved within minutes. This is often attributed to the cotton placement's ability to divert airflow and restore nasal resistance. Patients may be suitable candidates for inferior meatal implants if their ENS6Q score, a validated disease-specific questionnaire for ENS, has decreased by more than seven points. The clue of that test is to learn more about the physiological processes that account for the alterations in upper airway breathing after the insertion of a cotton plug in light of these findings and implications (Huang et al., 2022; Li et al., 2018).

Treatment

To reduce the incidence of ENS, turbinate conservation is essential for endonasal, sinus, and rhinoplasty procedures (Moore and Kern, 2001). When turbinal hypertrophy is unresponsive to medicinal treatment, inferior turbinectomy is a typical operation for nasal blockage (Scheithauer, 2010). Surgery used to strive for maximal resection in order to maximize the volume of the nasal cavity; however, current views encourage conservative surgery due to advancements in understanding the complications of complete and partial turbinectomy, including ENS. Several surgical approaches are performed to manage nasal obstruction while minimizing the risk of Empty Nose Syndrome (ENS).

Laser surgery and electrical cauterization are used to target nasal tissues precisely, reducing volume with minimal damage to surrounding structures. It's also common to perform partial turbinectomy, which involves removing no more than 50% of the turbinate volume to preserve airflow regulation and mucosal function. Submucosal turbinoplasty is another surgical method that reduces turbinate volume by resecting the bone while protecting the mucosa, which is crucial for maintaining nasal hydration and sensory feedback. Submucosal resection, on the other hand, with a micro-debrider, removes turbinal bone with precision while conserving the mucosal surface.

These methods prioritize mucosal preservation and functional outcomes to ensure effective treatment with fewer complications. Reducing the capacity of the nasal cavity to improve airflow resistance, decreasing airflow to enhance air humidity, and redirecting airflow from the surgical site to a healthy or non-operated area are the goals of endonasal repair surgery (Houser, 2007). The idea is to place an implant on the floor, lateral wall, or septum (Chhabra and Houser, 2009; Li et al., 2018; Rice, 2000). In ENS, one of the surgical options is to create a neo-turbinate. Although methods differ from team to team, the outcomes have been positive. The material should provide adequate and well-tolerated nasal cavity volume restoration with a low risk of extrusion, rejection, and infection.

A turbinal or septal cartilage transplant has been implanted submucosally to restore inferior turbinate volume. Restoring a mucosal surface large enough to support the physiological processes of air warming, filtration, and humidification is the goal (Malik et al., 2019; Li et al., 2018). In the few studies that have been reported, exogenic materials (hydroxyapatite, Goretex, Teflon, and plasticware) have also shown positive outcomes; they appear to prevent rejection and allow for a long-lasting increase in turbinate volume (Chhabra and Houser, 2009; Houser, 2007). Another injectable compound that appeared to alleviate symptoms without exacerbating them was hyaluronic acid gel (Malik et al., 2019; Rice, 2000; Cook et al., 1995).

There is still debate over the extent of volume restored by surgery and how long its effects last (Houser, 2007; Li et al., 2018). A method of submucosal acellular dermis graft filling was reported by (Houser, 2007). Within three to six months, the dermis began to integrate, and the resulting volume demonstrated long-lasting efficacy. Considering the tiny numbers involved in the various series, these results are intriguing but challenging to evaluate.

Given the potential psychological effects of surgical failure, we advise neuropsychological therapy prior to any decision to operate. In all situations, indications should be carefully addressed. Only when there is some residual turbinate are these methods feasible? Otherwise, surgery faces a more complicated challenge. It has been suggested that the inter-sinonasal wall be medialized or volume augmented; medialization appears to yield average results and carries the danger of obstructing the lacrimal duct (Fischer et al., 2000).

4. CONCLUSION

Empty Nose Syndrome (ENS) has a significant impact on both physical and emotional health. This condition arises from a complex interplay of structural, neurological, and psychological factors, which makes diagnosis and treatment challenging. Healthcare professionals should develop more diverse and personalized treatment strategies to improve patient outcomes.

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Author's Contributions

Zuzanna Kudas: Conceptualization; writing - rough preparation; supervision

Nikola Perchel, Paweł Nowocin, Martyna Koszyk, Aleksandra Litwin, Karolina Krzywicka, Dawid Wiktor Kulczyński: Writing - rough preparation

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Data and materials availability

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