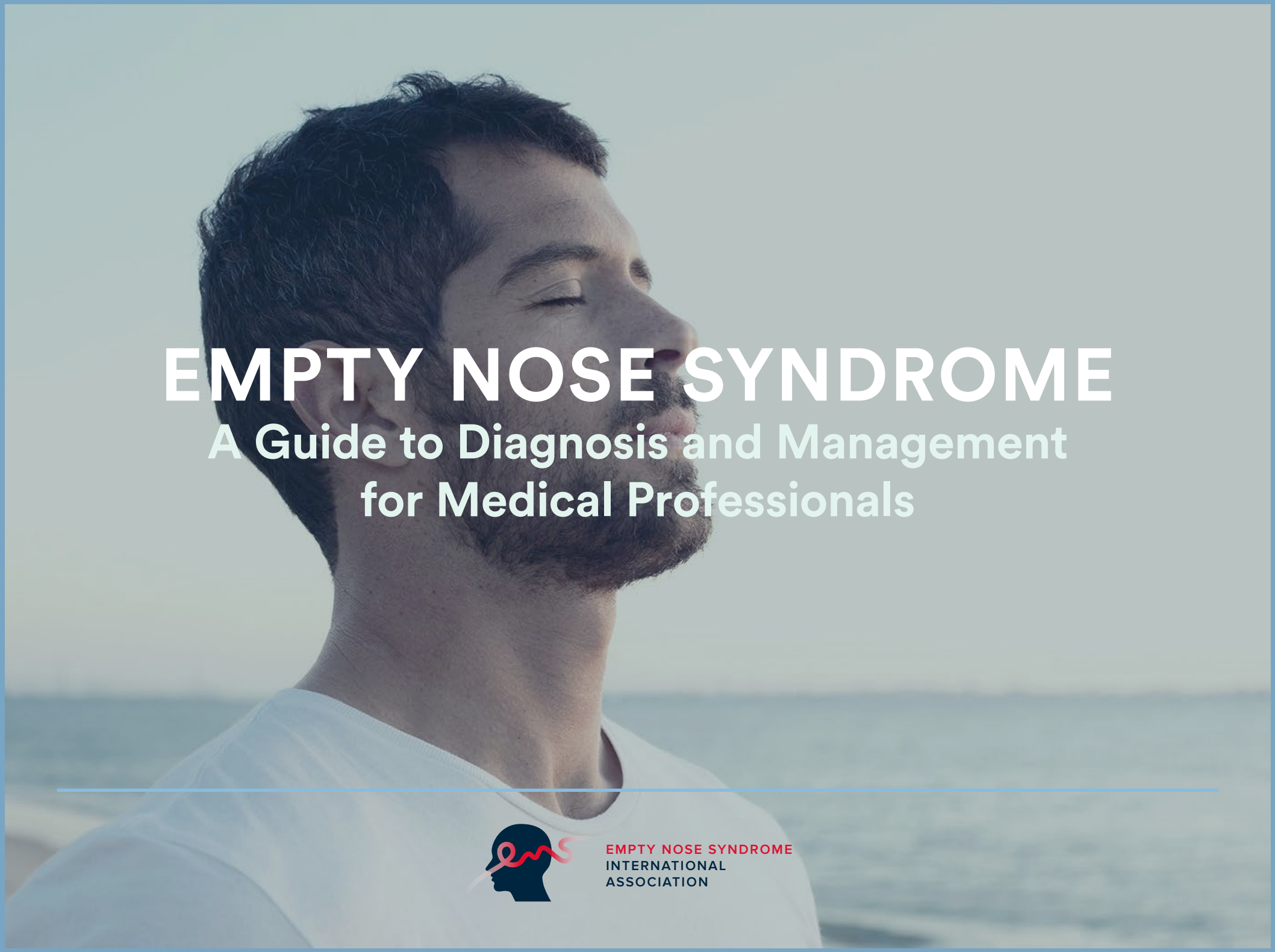

EMPTY NOSE SYNDROME

A Guide to Diagnosis and Management for Medical Professionals

EMPTY NOSE SYNDROME
INTERNATIONAL
ASSOCIATION

ABOUT US

Empty Nose Syndrome International Association (ENSIA) is a registered non-profit and is dedicated to providing support and information to individuals affected by this disabling condition. There is currently no cure for Empty Nose Syndrome (ENS).

ENSIA was founded in 2014, to raise awareness about ENS and support research into its treatment.

ENSIA offers the following services to its members:

- A subscription to the monthly ENSIA Newsletter;
- A website with members only area including: access to an ENS-Friendly Doctors list with descriptions of current treatments, advances in the ENS research, ENSIA's projects & initiatives, and other important information;
- A variety of materials on ENS and a database of ENS-related literature;
- ENSIA publications including "A Guide to Diagnosis and Management for Medical Professionals";
- and others.

ENSIA promotes research and education into the cause and treatment of Empty Nose Syndrome. We aim to raise awareness about ENS and encourage the medical profession to take an interest in the condition.

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TABLE OF CONTENTS

BACKGROUND

As a surgical complication secondary of turbinate surgery, Empty Nose Syndrome is an uncommon condition, which is underdiagnosed and is frequently untreated. There is a common misperception among some medical professionals that ENS is not severe or substantially disabling and can be managed with conservative treatments. This perception has resulted in ENS being little studied and largely overlooked, with a general lack of proper attention in both research into its cause and, more importantly, into its cure.

The purpose of this document is to provide guidance for medical professionals concerning diagnosis, management, and treatment of ENS.
The information contained herein is based on current medical literature and experience with ENS patients. The information should be considered advisory only.

ABOUT ENS

History

The term Empty Nose Syndrome was first coined by Dr. Eugene Kern of the Mayo Clinic in 1994. Dr. Kern described the condition and studied patients, many of whom had experienced total turbinectomies, a procedure which had seen a resurgence in the 1970's (lasting through the 1990s) having been earlier abandoned following condemnation around the turn of the century. The condition in connection with turbinate procedures, especially the turbinectomy, was known by the late 19th century (described as atrophy).

Definition

Empty Nose Syndrome is an iatrogenic disorder - a complication of nasal surgery - where the nasal turbinates, especially the inferior turbinates, have been excised or damaged as a result of turbinate surgery causing the destruction of normal nasal physiology. This leads to clinical symptoms of paradoxical obstruction *, nasal dryness, crusting, intermittent bleeding, lack of airflow sensation, nasal and upper respiratory dryness/irritation/pain from unprocessed/cold/dry inspired air, disruption in nervous system function, and number of secondary symptoms. In brief, ENS can be considered a nasal breathing disorder (characterized by paradoxical obstruction) along with concomitant nasal dryness (atrophy) [1] [2].

Statistics and Incidence rate

Empty Nose Syndrome affects a small number of the population and the incidence is not known because there are no specific studies which have investigated the incidence of ENS. The absence of incidence-related studies is directly related to the lack of awareness about ENS among medical professionals. This has resulted in the absence of diagnostic criteria and omission of a diagnosis of ENS in patient records.

Causes

ENS occurs following turbinate surgery and can emerge months to years afterward. Any turbinate procedure has the potential to cause ENS if it is performed too aggressively. Some turbinate procedures increase the likelihood of ENS, such as partial or total resection of the inferior nasal turbinates, or mucosal surface cautery [3]. Risk of ENS increases the greater the turbinates are excised or damaged. Total turbinectomies are less common today following the resurgence of the 1970's and are frowned upon, especially within the specialty of otorhinolaryngology, however, there is no general prohibition against them.

* Feeling of nasal obstruction is described as constant and continuous: feeling of suffocation, inability or significant difficulty to breathe through nose, feeling that nose is too open, sensation of excessive airflow, shortness of breath, difficulty to properly inflate the lungs, lack of nasal resistance, and/or undifferentiated breathing difficulties.

Currently, there is no consensus concerning how much turbinate excision or damage can result in ENS, nor what measure of excision or damage constitutes an “aggressive” reduction. On the subject of ‘how much is too much?’, there exist no quantifying studies, guidelines, or formal statements issued by professional bodies.

Features of ENS

ENS shares features in common with secondary atrophic rhinitis, but current research has distinguished it as a separate condition. Despite ENS lacking a diagnostic consensus, most ENTs consider ENS to be a true clinical entity, and its primary features are agreed upon. ENS is a multifactorial condition, which arises due to a combination of structural and functional impairments of the vital nasal structures, involving altered nasal aerodynamics, reduced and impaired mucosal area, and neurosensory damage (e.g. damage to cool thermoreceptors) [4].

ENS patients have significant difficulties including:

- constant dyspnea and/or a sensation of suffocation;
- sleep deprivation;
- nasal, facial, and respiratory dryness, coldness, irritation, and pain;
- increased illnesses from damaged nasal physiology such as recurrent sinus infection, bronchitis, asthma;
- a disrupted nasal cycle;
- autonomic nervous system dysfunction;
- a variety of other medical complications secondary to ENS.

ENS is a debilitating and disabling condition, resulting in a poor quality of life since good nasal function is crucial for proper lung functions and breathing, body’s oxygenation, ability to function physically, proper functioning of nervous system, cognitive functions, and sense of well-being. ENS patients suffer substantially and continuously.

Mouth breathing is not a reasonable alternative, since it is not a physiological method of respiration and should never be considered a substitute for nasal breathing. Nasal airway resistance accounts for more than 50% of total airway resistance and increases oxygen (O2) uptake by 10-20% [5]. Mouth breathing does not alleviate ENS symptoms.

Diagnosis

Formerly, the difficulty has been in obtaining objective diagnostic evidence, rather than subjective symptomatology of patients (derived, for example, from the Sino Nasal Outcome Test, SNOT). Even so, conditions such as tinnitus are diagnosed despite there being a similar impediment to diagnosis. However, there are a number of diagnostic tools, some of which are new, some of which have not been routinely employed in the diagnosis of ENS. ENS is currently able to be diagnosed within the clinical setting, and diagnosis is able to be further supported by diagnostic tools available outside the clinical setting.

Treatment, Prognosis, Quality of Life

Conservative management of ENS focuses on irrigation and moisturizing of the nose to preserve remaining mucosa and needs to be performed for the patient’s lifetime. The necessity for chronic nasal care is burdensome and time consuming.

While nasal reconstructive surgery and regenerative medicine treatments can result in some improvement in symptoms, it is important to remember that turbinate tissue cannot be replaced or regrown, and there is no cure for ENS.

ENS patients experience a significant reduction in quality of life (QOL). ENS has an impact on physical health, employment, marital, social, and financial aspects of the patient's life. As a chronic illness, ENS can have an impact on the patient's well-being and reduce his/her enjoyment of life, inducing stress and secondary symptoms like anxiety and depression. ENS can cause inability to work or significant number of 'sick days missed from work, decreased productivity, and lifestyle disruption [6]. There are memory and concentration deficits caused by abnormal breathing, the lack of sleep, a diminished sense of smell, and lack of nasal sensation which also lower QOL.

ENS produces environmental limitations for the patient in windy, dry, cold, hot, air-conditioned, heated, dusty or odor-filled places, because the nose can no longer properly fulfill its functions (filtering, humidifying, dehumidifying, warming, smelling, and safeguarding).

To place the symptoms and sequelae of ENS in context, a diminished sense of smell (hyposmia) in and of itself can be considered a major contributor to reduced QOL.

These difficulties in their total can result in the ENS patient suffering from general disability, that is, a difficulty functioning and performing daily activities.

To assess of quality of life of ENS patient it is advisable to use the **Rhinosinusitis Disability Index (RSDI)**. Another generic assessment instrument for health and disability is the **WHO Disability Assessment Schedule** [7].

Statistics

ENS is considered a rare condition, affecting a small subset of patients who undergo turbinate reduction. However, the true incidence is unknown since there have been no specific studies published investigating the incidence. This is due to the fact that there is a lack of information concerning the condition and no universal definitional/diagnostic consensus. A 22.2% incidence of atrophy following inferior turbinectomy was reported in a long-term study [8]. Other estimates say that 20% of patients with resection will develop fulminant ENS and a greater percentage will suffer dryness or changes in airflow [9].

The most recent data from 2006 suggest there are an estimated 196,000 turbinectomies in the United States according to National Center for Health Statistics [10]. Turbinectomies often are performed as secondary procedures in conjunction with surgeries such as functional endoscopic sinus surgery (FESS) and/or a septoplasty. Since this figure does not include turbinectomies performed in conjunction with other sino-nasal surgeries, the number of turbinate surgeries is likely much higher [11].

In addition, a portion of the middle turbinates may be resected during FESS or other procedures in order to facilitate access to certain areas of the nose.

Clinical presentation

Nasal dryness and breathing difficulties are the most common presenting symptoms with paradoxical obstruction being considered the hallmark symptom. Patients complain of stuffiness or emptiness despite having a patent nasal cavity. They may also describe a feeling of lack of nasal resistance, difficulty to properly inflate the lungs, breathlessness, suffocation, or lack of nasal airflow sensation. Nasal dryness presents on a continuum ranging from simple dryness to atrophy. Mucosa can appear pale and dry. There may be thick or absent secretions. Thick secretions can cause congestion, pressure,

and pain. Crusting is often present, with significant crusting in more severe cases. Additionally, there may be significant nasal and facial pain caused by mucosal dryness, atrophy, or neural damage. Hyposmia and hypersensitivity to volatile compounds ** can both affect the patient's sense of smell and quality of life. Symptoms can range from mild to extremely severe.

Patients presenting with ENS can have a substantial loss of mucosal turbinate tissue, or can have normal appearing turbinates and intranasal volume (having suffered functional damage to the turbinates). Clinical presentation within the ENS population varies. Patients upon nasal examination may vary in appearance due to the method and amount of turbinate reduction. This is due to the fact that it is not known how much turbinate tissue can be removed or damaged before nasal physiology is compromised or before the aerodynamic pattern of the nasal cavity becomes impaired. Symptomatology may vary in number of symptoms and severity, but the well-established primary symptoms of ENS are often universally present, the core of which comprise Houser's five modifications to the SNOT-25. Since the onset of ENS can occur at an interval ranging from weeks, months, to years, the patient's turbinate procedure may have been recent or taken place some years prior.

ENS Subtypes

ENS has been classified into four subtypes:
ENS-IT, ENS-MT, ENS-Both, and ENS-Type [12].

The subtypes describe the following:

- IT - where the inferior turbinate has been partially or totally excised;
- MT - where the middle turbinate has been partially or fully excised;
- Both - where the inferior and middle turbinates have been at least partially excised or reduced;
- Type - where a patient has sufficient-appearing turbinate tissue, but suffers ENS symptoms after surgery affecting the mucosal surface of the turbinates [13].

Complicating Factors

Common findings of complicating factors may include:

- additional nasal openness from concomitant septoplasty (which can affect/diminish the septal swell body);
- septal perforations;
- structural collapse, such as nasal valve collapse;
- large sinus openings and absent nasal structures from overly aggressive sinus or nasal surgery that facilitate unphysiological ventilation;
- mucosa affected by age, autoimmune disease or hormonal status (e.g. geriatric rhinitis, Sjogren's syndrome, and menopause).

It is important to inquire of the patient about his moisturizing habits. Use of humidifiers, saline, and emollients may interfere with examination-based evaluation of nasal dryness. A nose with healthy physiology does not require any moisturizing.

** Volatile compounds - gasoline, perfume, smoke, smells, etc.

A Note on Patients Presenting with ENS

Patients presenting with ENS for clinical examination are often in distress. They will commonly have been suffering for a considerable length of time without relief from severe breathing difficulties, damaged sensory ability, severe nasal dryness with its attendant acute burning and pain, and from acute sleep deprivation. The majority of patients have no understanding of nasal physiology and are unfamiliar with related symptoms. They often have difficulty expressing symptoms. Among the most difficult symptoms is *paradoxical obstruction*. Patients with significantly resected turbinates may suffer from lack of nasal resistance necessary for efficient respiration and pulmonary gas exchange. Additionally, patients may experience lack of airflow sensation, which creates conflict in signals between their nose and central nervous system (brain). This results in a sense of suffocation. Patients feel that they have lost control of their breathing, sleep, and important sensory input (airflow, temperature, smell), in addition to the pain of severe nasal dryness and unprocessed airflow in the upper respiratory tract due to excessive nasal openness. This situation often results in a heightened state of anxiety and may trigger a continuous "fight-or-flight" response in patients.

Table 1: lists common patient complaints:

- Nose feels too open/empty
- Getting too much air (excessive airflow)
- Breathlessness and/or feeling of suffocation
- Feeling of hyperventilation
- Difficulty to inflate lungs/draw a full breath
- Lack of airflow sensation
- Cold, dry, unprocessed air hitting the back of throat
- Severe dryness with/without crusts
- Burning/pain in nose
- Nose feels numb
- Unable to sleep because of difficulty breathing
- Cannot find right way to breathe through the nose
- Unable to relax/feel like nervous system is going "crazy"

SYMPTOMS

ENS symptomatology has been assessed utilizing the SNOT 20 or 22 (Sino-nasal Outcome Test). Subsequently, the SNOT-25 has been utilized to assess ENS symptomatology [14]. The new ENS6Q (Empty Nose Syndrome 6 Questionnaire) has also been used for assessment.

ENS-specific questions are contained in both the SNOT-25 and the ENS6Q. The SNOT-25 contains five (5) items specific to ENS [15]. The ENS6Q is a validated ENS-specific, 6-item questionnaire, which can be used as an adjunct to the SNOT-22 to screen patient for ENS [16].The ENS6Q includes four (4) of the ENS-specific items from the SNOT-25, adding two new items: sense of diminished airflow (cannot feel air flowing through your nose) and nasal burning.

SNOT-55

ENSIA has proposed a fifty-five (55) item modified SNOT test to assess ENS symptoms. This proposed SNOT-55 builds on SNOT-25 adding thirty (30) new items.

These new items define symptoms that have been widely discussed and thoroughly described by ENS sufferers in support groups over the past 10 years.

Some of these new items have previously been described in the works of SM Houser, EB Kern, and in the book of patient (and ENS sufferer) Christopher Martin, but have heretofore not been applied specifically in a test or measure [17].

The thirty questions are scored from 0-5 with higher scores indicating greater ENS-related disease burden (health concerns) including physical & emotional problems and functional limitations.

Description of items

Items 1-25 comprise the SNOT-25. A large number of new items in the SNOT-55 are related to the 'breathing disorder' component of ENS. These include items 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 40, & 54. Breathing-related symptoms vary among ENS patients and can differ based on the method and extent of turbinate reduction.

The number of breathing-related items contained in SNOT-55 reflect this variation. For example, a patient with a large resection may experience breathing difficulties differently than someone who has seemingly adequate turbinate tissue that has experienced surface cautery. Additional rhinological symptoms are included as items 41 through 47. Other secondary physical symptoms are listed as items 48 through 50. Cognitive and functional limitations are expanded upon in items 51 through 55.

Table 2: SNOT-55

(ENS-specific symptoms from #21-55)

No.	SNOT – 55
Nasal Symptoms:	
1	Need to blow nose
2	Sneezing
3	Runny nose
4	Cough
5	Postnasal discharge
6	Thick nasal discharge *(thick mucus)*
7	Ear fullness
8	Dizziness
9	Ear pain
10	Facial pain/pressure
11	Difficulty falling asleep
12	Waking up at night
13	Lack of good night's sleep
14	Waking up tired
15	Fatigue
16	Reduced productivity
17	Reduced concentration
18	Frustration/restlessness/irritability
19	Sadness
20	Embarrassment
Houser Modification adds:	
21	[Nasal] dryness
22	Difficulty with nasal breathing
23	Suffocation
24	Nose is too open
25	Nasal crusting
ENSIA Modification adds:	
26	Nasal obstruction *(blockage /congestion of nose)*
27	Nasal emptiness
28	Excessive airflow *('too much air')*
29	Decreased nasal resistance
30	Shortness of breath *(dyspnea)*
31	Difficulty to inflate lungs
32	Difficulty drawing a full breath
33	Disturbed/disorganized airflow
34	Decreased sense of nasal airflow
35	Weakened airflow *(weak stream of inhaled air)*
36	Tight, asthma-like breathing
37	Use of accessory muscles (neck and chest) to facilitate breathing
38	Respiratory dryness/coldness/irritation of pharynx & adjacent areas *(breathing unprocessed air)*
39	Hypersensitivity to volatile compounds *(e.g. gasoline, perfume, smoke, smells, etc.)*
40	Rapid breathing
41	Reduced sense of smell
42	Lack of mucus
43	Nasal burning/pain
44	Nasal bleeding
45	Nasal inflammation
46	Impaired nasal drainage
47	Difficulty removing thick mucus/clearing nose
48	Dry eyes
49	Headache
50	Increased heart rate
51	Impaired concentration from breathing difficulties *(aprosexia nasalis)*
52	Anxiety
53	Increase in symptoms in windy, dry, cold, hot, air-conditioned, heated environments
54	Persistence of symptoms when mouth breathing
55	General disability *(difficulty functioning, performing daily activities)*

Table 3: ENS Symptoms with Definitions

Each symptom is provided with a definition.

21 [Nasal] Dryness The consequence of the decompensation of the humidifying function of the nasal mucosa due to absent or dysfunctional turbinate tissue. Nasal mucosa can appear dry upon exam, or even atrophic.	22 Difficulty with nasal breathing Nasal breathing is made difficult by the changes in the nasal cavity following turbinate resection including: neurosensory damage, impaired aerodynamics, decreased nasal resistance, paradoxical obstruction from an overly patent airway. Patients can suffer from some or all of these changes.	23 Suffocation A sensation of suffocation is produced by a lack of nasal resistance necessary for efficient respiration & pulmonary gas exchange, and a lack of airflow sensation, which creates conflict in signals between the nose and central nervous system (brain).	24 Nose is too open Refers to a sensation that the patient's nose is too open due to lack of turbinate tissue. Patients may feel their nose is too open to airflow or to the environment. There can a sensation of excessive openness even while at rest which conveys a sense of vulnerability or lack of protection to the patient. Anxiety is a common response to this symptom.
25 Nasal crusting Hardened crusts that can develop in the dry nose from dried mucus, sores, and chronic bacteria. They can be painful and affect breathing.	26 Nasal obstruction *(blockage / congestion of nose)* The feeling the nose is obstructed. In context of ENS, it is paradoxical obstruction – sensation of nasal obstruction despite a widely patent airway.	27 Nasal emptiness The sensation of absence or emptiness of the nose. Refers to the lack of nasal sensation due to removal of nasal structures and/or nasal neurosensory damage.	28 Excessive airflow *("too much air")* Refers to a sensation that the patient is breathing too much air, or breathing too freely.
29 Decreased nasal resistance Decreased values of nasal resistance in both inspiration and expiration occur in ENS. Adequate inspiratory resistance is necessary for efficient respiration and efficient gas-exchange in the alveoli of the lungs. Experienced in ENS as an absence of necessary "force" for adequate respiration.	30 Shortness of breath (dyspnea) Dyspnea. A feeling that one cannot breathe adequately. Can be related to a feeling of suffocation.	31 Difficulty to inflate lungs The feeling there is difficulty to inflate the lungs upon nasal inspiration. It is a feeling of shallow breathing. Due to changes in the nasal cavity - nasal resistance, airflow impairment.	32 Difficulty drawing a full breath Refers to the feeling of inspiration being limited to the upper chest, lacking diaphragmatic involvement. Due to decreased nasal resistance affecting pulmonary function. Impaired lung compliance may also be involved – such as bronchospasm due to inspiration of unconditioned air.
33 Disturbed/disorganized airflow A feeling of disorganized, disturbed airflow when breathing. Caused by changes in the nasal cavity following surgery.	34 Decreased sense of nasal airflow A phenomenon where the sensation of breathing is decreased or absent. Caused by damaged or lack of sensing nerve receptors of the inferior turbinate. Airflow can be sensed in the lungs, but not in the nose	35 Weakened airflow *(weak stream of inhaled air)* Refers to the sensation that there is a weakened stream of airflow at a decreased velocity with inspiration. The sensation extends to a perception of shallow breathing.	36 Tight, asthma-like breathing Asthma-like symptoms such as bronchospasm and airway stenosis occurring as a result of inspiring unconditioned/unprocessed air and/or lack of nasal resistance.

37 Use of accessory muscles (neck & chest) to facilitate breathing Use accessory muscles of the neck and chest to produce force and resistance within the upper airway & thoracic areas in order to facilitate breathing.	38 Respiratory dryness/coldness/irritation of pharynx & adjacent areas *(breathing unprocessed air)* A sensation of dryness, coldness, irritation in the pharynx and adjacent areas, especially noticeable when inspiring air. From the inspiring of unconditioned, unprocessed air. A central patient complaint indicative of ENS is dry, cold air hitting the back of the throat when breathing.	39 Hypersensitivity to volatile compounds *(e.g. gasoline, perfume, smoke, smells, etc.)* Refers to sensitivity to volatile compounds despite having reduced sense of smell generally. Possible reasons are changes in airflow, nasal emptiness, and dryness. The patient may experience nausea and irritant reactions.	40 Rapid breathing Rapid breathing can be either shallow or deep. Decreased nasal resistance can result in shallow breathing and increased breaths per minute. Decreased nasal airflow sensation may produce deep breathing as the patient struggles to sense adequate air intake, placing themselves in a state of hyperventilation. Both can occur under different circumstances and is also influenced by the type of turbinate reduction and surgical alterations of the nasal cavity as well as patient compensatory response to breathing impairment. Breathing at rest typically results in shallow breathing, while breathing with exertion or under stress produces the latter.
41 Reduced sense of smell Hyposmia - a reduced ability to smell and to detect odors. May be caused by altered airflow patterns, in particular lack of high inspiratory airflow, affecting olfactory stimulation/perception. Some ENS patients can suffer from anosmia.	42 Lack of mucus Turbinate tissue is rich in nasal glands. Absent, not sufficiently stimulated (due to decreased pressure and shear stress conditions as a result of resection of nasal structures), and/or damaged turbinate tissue results in a lack of mucus and nasal dryness. The important function of mucociliary clearance (MCC) is damaged.	43 Nasal burning/pain Burning sensation and pain within the nasal cavity. Can be both at rest and with breathing exacerbated by airflow. Dry nasal mucosa, inflammation, and nerve sensitivity contribute to this symptom.	44 Nasal bleeding Epistaxis. Caused by dry, fragile, or atrophied nasal mucosa.
45 Nasal inflammation Nasal inflammation caused nasal dryness, decreased mucus, impaired or resected nasal glands and vasculature of the turbinates.	46 Impaired nasal drainage Nasal drainage is impaired due to structural changes within the nasal cavity. The mucociliary clearance (MCC) system is damaged.	47 Difficulty removing thick mucus/clearing nose Impaired nasal aerodynamics, unusually thick mucus, impaired mucociliary clearance, nasal dryness make blowing or clearing the nose difficult.	48 Dry eyes Dry eyes can occur as a result of chronic nasal dryness.

49 Headache Breathing difficulties can contribute to headaches; more so due to hyperventilation[18] or hypoxia. ENS-related sino-nasal symptoms contribute as well.	50 Increased heart rate Heart rate increased from the patient's normal rate. Need not reach tachycardia according to the "conventional rate limits for sinus rhythm" [19], but may be a pathology for the individual patient ***. Caused by breathing difficulties, dyspnea or feeling of suffocation, and lack of nasal sensation (triggering autonomic stress from lack of signaling to the breathing centers of the brain).	51 Impaired concentration caused by breathing difficulties *(aprosexia nasalis)* More broadly can mean impaired cognitive function. Two descriptions of *aprosexia* from 19th century medical literature noted: "functional disorder of the brain, caused by disturbed nasal respiration" and "want of concentration".	52 Anxiety Physically generated anxiety is that induced by breathing difficulties, decreased airflow sensation, and autonomic disturbances.
53 Increase in symptoms in windy, dry, cold, hot, air-conditioned, heated environments Patients experience an increase in symptoms both indoors and outdoors in windy, dry, cold, hot, air-conditioned, heated environments. Environment-related limitations affect ability to function and daily activities of work, social, physical (exercise), and general enjoyment of life.	54 Persistence of symptoms when mouth breathing Symptoms do not improve or resolve with mouth breathing.	55 General disability *(difficulty functioning, performing daily activities)* Symptoms and sequelae of ENS result in the patient being in a state of general disability.	

*** A heart rate of 90 bpm being a norm for one patient can be a 50% increase in heart rate (tachycardia) for a patient with norm of 60 bpm.

PATHOPHYSIOLOGY

ENS is a complication of turbinate surgery, where the turbinates have been excised or damaged resulting in impairment or loss of nasal physiological functions. Total turbinate excision is the most frequent cause, but other procedures can cause it as well. All turbinate procedures have the potential to cause ENS if performed too aggressively. Removal or reduction of the inferior turbinates are more likely to result in ENS, than are the middle turbinates. Some turbinate procedures increase the risk of ENS, such as total turbinectomy or surface cautery [20].

Significant studies concerned with pathophysiology of ENS are those of EB Kern and SM Houser [21,22].

ENS is a multifactorial condition [23]. Factors contributing to the ENS include: alteration of airflow pattern, reduced mucosal area, decreased humidification and increased warming, reduced nasal airflow resistance, loss of sensory, tactile and thermal receptors needed for inhaled air treatment, and neural damage [24,25]. These changes are related to the alteration of pulmonary function [26].

It is not known how much turbinate tissue can be removed or damaged before causing ENS. Descriptors like “over-resection”, “aggressive”, or “excessive” populate the literature as a characterization of what level of excision or damage can result in ENS. However, these descriptors have not been quantified in any studies, nor are they described in any set of professional guidelines. The majority of patients treated for ENS have experienced significant resections or reductions and/or had surgery involving mucosal-damaging techniques.

Cool thermoreceptors

Paradoxical obstruction is a central feature of ENS, where patients commonly suffer from nasal obstruction and a decreased nasal airflow sensation despite a patent airway. Since sensation of nasal patency is related to trigeminal activation of cool thermoreceptors though mucosal cooling, research focused on this issue has proposed a link to nasal cool thermoreceptors as a factor in ENS [27]. Findings indicate that the perception of nasal airflow by means of mucosal cooling is a more significant factor in ENS than air temperature or nasal resistance are [28]. As it applies to ENS, patients with wide nasal passages may produce less mucosal cooling [29].

For example, in the case of a total inferior turbinectomy (TIT), computational fluid dynamics (CFD) study has revealed that in addition to a decrease in nasal resistance, nasal heating and humidification efficiencies are reduced to 60%-80% of their pre-surgical measures (near 100%) [30]. Additionally, the optimal nasal air-conditioning is necessary for pulmonary gas exchange in order to avoid desiccation and adhesion of the alveolar capillary bed [31].

These receptors, along with other nasal receptors (mechanoreceptors, proprioceptors, and warm thermoreceptors), which cover the nasal epithelium, may be absent due to turbinate excision or damaged - either due to mucosal damage secondary to mucosal-damaging turbinate procedures or to mucosal atrophy.

Airflow

Computer airflow modeling studies show that there is significant airflow and aerodynamics disruption in the nose following resection of nasal turbinates [32]. It is thought that changes in aerodynamics play a central role in ENS. Turbulent airflow and decreased nasal resistance are characteristic of ENS. Turbinates act as resistors to, first, participate in the breathing function to expand the lungs, and, second, to direct the air in a streamlined, laminar pattern of airflow. Nasal resistance in the ENS nose demonstrates below normal values, and thus, the term “decreased nasal resistance” connotes below normal values of nasal resistance in both inspiration and expiration [33].

Both actions are integral to pulmonary function. Adequate nasal resistance is necessary to for sufficient fulfillment of respiratory function: optimizing alveolar ventilation, preventing alveolar collapse, and maintaining elasticity of the lungs. Too little nasal resistance (also mouth breathing) can result in micro areas of poor ventilation in the lungs [34].

In addition, decreased nasal resistance can also impair sensation of airflow. Excessive nasal emptiness and turbulence can increase drying of the nasal mucosa, having a downstream effect on nasal physiology.

In contrast to the normal nose, where airflow is evenly distributed, disruption of aerodynamics in the ENS nose leads to dyspnea and other undifferentiated breathing difficulties. Nasal resistance contributes approximately half the resistance of the airways. Even small changes in nasal resistance affect total respiratory function [35].

Dyspnea can also be explained by study results, which support the fact that mucosal cool thermoreceptors are connected to respiratory centers in the brain [36].

Dryness/mucosal atrophy

Progressive or non-progressive mucosal atrophy is quite common among ENS patients. Impaired mucosa regeneration due to mucosal atrophy or dysfunction leads to greater vulnerability of the nasal epithelium and impaired mucociliary transport. The moisture in the nose is reduced since the mucinous cells are impaired or missing, and nasal secretions decrease. Impaired local defenses against infections can cause mucosal swelling together with constant nasal inflammation and infections [37].

Mucociliary clearance

Diminished or absent mucociliary clearance and unusually thick mucus are common features of ENS. An impaired system can result in chronic sinusitis for some patients, particularly those with total turbinectomies. A study found that 50% of patients with total turbinectomies who had no sinusitis before developed chronic sinusitis following surgery [38].

Neuropathy

Neural damage is thought to be a contributing factor in ENS. Damaged nerve fibers from turbinate surgery may play a role, although there is little evidence specifically.

Additional risk factors for ENS have not been studied, but some factors have been proposed including: climatic conditions, an underlying connective tissue disorder, poor wound healing, poor regrowth of sensory nerves injured in turbinate surgery, aging mucosa, and others.

DIAGNOSIS

Diagnosis of ENS should be considered in any patient complaining of nasal dryness and breathing difficulties following turbinate surgery. Suspicion of ENS is not excluded in patients who have seemingly adequate turbinate volume or who do not appear to have nasal dryness upon endoscopic or nasal examination. Since ENS is multifactorial, multiple tests are necessary to confirm diagnosis of ENS.

ENS can be diagnosed both objectively and subjectively. Current diagnostic method relies on subjective reported symptomatology (SNOT-25) or ENS6Q and a positive "cotton test". Radiographical and nasal endoscopy findings also contribute to the diagnosis. Nasal dryness shows a good correlation with the degree of turbinate tissue loss [39].

Objective tests can include imaging, computational fluid dynamic (CFD) study, manometry, pathology (e.g., squamous metaplasia), and endoscopy. Many of these tests are easy to administer in the clinical setting.

While diagnosis has emphasized this current diagnostic method, other tools of diagnosis which are not routinely utilized should be considered. These tools are described below in this section.

Objective tests

CFD (aerodynamics)

CFD (Computational Fluid Dynamics) is the most advanced, precise, and objective test used in assessment of nasal aerodynamics. It computes the airflow pattern, unilateral airflow allocation, regional airflow distribution, nasal resistance, airflow velocity, aerodynamic load ****, vorticity, and other parameters in different sections of the nasal cavity.

CFD studies show decreased (below normal) nasal resistance levels and diminished airflow rates with more chaotic streamlines in the inferior turbinate resected population [40].

Rhinomanometry

While not definitive for ENS, rhinomanometry is useful to confirm nasal patency, and more importantly, confirm lower than normal rates of nasal resistance characteristic of ENS. While computational fluid dynamics (CFD) study may provide better data for ENS on nasal resistance, the availability of rhinomanometry as a clinical tool makes it a useful contributor to diagnosis.

**** Aerodynamic load - the distribution of pressure and shear stress represent a distributed load over the surface.

It should be noted, however, that rhinomanometry is not as useful to assess the patient's subjective nasal patency and may produce biased results for ENS patients.

Mean total resistance in normal subjects is .23 Pa/cm3/s, ranging between .15 Pa/cm3/s and .39 Pa/cm3/s [41].

Computer Tomography

CT findings indicative of ENS are: mucosal thickening of the paranasal sinus lining and enlargement of the intranasal space with bowing of the nasal walls [42]. Two other radiographic findings may indicate ENS as a recent study found. According to a study, the mucosal thickness of both the central and posterior segments of the septum in ENS subjects is significant when compared to non-ENS subjects [43].

Cotton test

This is both a diagnostic test and a pre-therapeutic test. Cotton soaked in saline is placed in the nasal cavity in an area of deficit where an implant may be positioned. The cotton remains in place for about 30 minutes during which time the patient is asked to breathe comfortably. If there is subjective improvement in breathing, and a change in sensation or symptoms, this is considered a positive result and indicative of ENS. Patient report that they experience more relaxed breathing and a decrease in suffocation.

The cotton test may not be as useful for ENS-type patients who have seemingly adequate tissue, and may have suffered damaged turbinate mucosa. The utility of the cotton test remains to be validated [44].

Biopsy

Nasal biopsy may confirm evidence of squamous metaplasia of the nasal epithelium. Histological features are: loss of normal pseudostratified columnar epithelium, serous mucus and glandular atrophy, loss of cilia, loss of goblet cells, inflammatory cell infiltrate and endarteritis obliterans [45].

Biopsy can gauge mucosal condition, since mucosal metaplasia (and dryness) may not be visible upon exam. Metaplasia may be limited to patches of the epithelium (partial) or be more extensive depending on the state of the disease process. Squamous metaplasia may not be present in all ENS patients because some patients experience ENS symptoms weeks to months after the turbinate surgery, and metaplasia is suggestive of long-term dryness.

A positive finding in a patient complaining of ENS symptoms is strong diagnostic indicator of ENS. Further studies are needed to examine the correlation between biopsy findings and symptoms of ENS, and standardize pathology criteria [46].

Intranasal Schirmer test

Nasal dryness is one of the most reliable symptoms for ENS diagnosis.

The intranasal Schirmer test is used to assess nasal secretion and nasal mucosal moisture. Filter paper strips are placed bilaterally along the anterior septum for 10 minutes and the median wetting distance is evaluated. In a preliminary study to quantify nasal secretion, the median wetting distance of the normal (healthy, non-smokers) group was 10.3mm (range 3.6-35.0mm), and the smoking group was 8.4mm (range 2.5-28.0mm) [47].

The Schirmer test is already used widely in evaluation of dry eye to assess aqueous tear production and in evaluation of dry mouth to assess salivary gland hypofunction.

Endoscopy or nasal examination

Nasal endoscopy can be used for an assessment of the visual quality of the nasal mucosa. Mucosa may be dry and pale with crusting. The nasal epithelium may be fragile and bleed easily. Evidence of a turbinate reduction will be present and increased intranasal space may be present. Dryness can be confirmed on examination.

Saccharin Test

The saccharine test is used simple test of nasal mucociliary clearance (MCC). Mucociliary clearance sweeps the mucus layer toward the nasopharynx by ciliary action. Normal mucociliary clearance is less than 20 minutes. In the test, a saccharine particle is placed near the anterior portion of the inferior turbinate. If the patient takes longer to detect the sweetness than normal time, this is considered delayed or prolonged duration. This test is inexpensive and easy to perform [48].

Subjective Tests

Subjective tests include: SNOT-25, ENS6Q, and SNOT-55 - each as described in the **Symptoms** section above.

MANAGEMENT

At the present time, there is no cure for empty nose syndrome. However, in some cases symptoms can be managed or improved.

Conservative management

Conservative management does not differ substantially from that of secondary atrophic rhinitis and focuses on nasal hygiene and moisturizing nasal mucosa. Use of saline sprays and irrigations, gels, emollients, and humidifiers are meant to maintain the health of the remaining nasal mucosa and support the function of mucociliary clearance. Moisturizing nasal mucosa alleviates pain and discomfort from dryness, thick or absent secretions, prevents infection, reduces mucosal inflammation, irritation, improves breathing, as well as provides a protective barrier from the elements. Chronic dryness can lead to metaplasia, so it is important to keep the nose moist.

Patients need to be educated about the role of nasal hygiene and care and the use of topical agents in the management of ENS. Patient adjustment to the need for nasal care is often difficult – it is time consuming and requires a great deal of patient education. While conservative management should be encouraged, patients report that chronic use of saline spray and irrigations can be drying, and that gels and emollients can be irritating.

Moisture lasts minutes to a few hours, so patients are advised to repeat often as wished without generating too much additional irritation. ENS patients sometimes may have to use these tools sparingly so as not to worsen dryness or irritation. There is a role for topical corticosteroids and antibiotic ointment or therapy. Concern for lung health is important when selecting a product.

Frequency & duration of treatment

It may take many months of moisturizing to reach a level improvement where the patient is comfortable and no longer has severe burning, irritation, and pain. Moisturizing must continue regularly throughout the patient's lifetime. Patients with severe crusting may require removal of crusts by a physician. The short-lived effects of saline, irrigation, and emollients require the patient to repeat frequently in order to stay comfortable. Patients with thick mucus lodged deep in the nasal cavity that impedes breathing often need to remove mucus frequently throughout the day.

Basic aspects of care

Basic care may include:

- Daily nasal irrigations of saline and saline sprays;
- Emollient oils (e.g. sesame, rose geranium, etc.), ointments, and gels can provide some temporary relief in cases of severe dryness and crusts; oils containing menthol may increase sensation of nasal patency [49];
- Using air humidifier;
- Using a CPAP/APAP/AIRVO machine (preferably with an inbuilt humidifier);
- Using nasal filters or nose clips to create some resistance;
- Wearing protective masks (e.g. cold weather face mask or asthma mask) to protect respiratory system and lungs from the damaging effects of dry/cold air;
- Keeping in a humidified environment and avoiding windy, dry, cold, hot, air-conditioned, and heated environments (also environments with significant particulate smells, dust);
- Moving to countries/locations with warm and humid climate.

General Protocol for Nasal Moisturizing and Management of ENS

- Saline spray (preferably buffered)(e.g. Breathe-Ease® XL)
- Saline irrigation with or without steroid* (e.g. budesonide solution)
- Emollient oil (e.g. sesame or rose geranium oil), nasal ointment, cream, drops, or spray (e.g. Rinopanteina, Ponaris, Siccalix, Premarin, Nozoil, etc.)
- Antibiotic ointment (such as Mupirocin)

Select items with regard to irritation factor and effects on lungs.
*Patients report steroid solution is very drying. Long-term effects of corticosteroids in the ENS nose are unclear.

Advice on nasal hygiene and conservative management of ENS can be found in the book Having Nasal Surgery? Don't You Become an Empty Nose Victim!, written by ENS sufferer, Christopher Martin [50].

Saline Spray and Irrigations

Moisturizing the nose with saline spray or irrigations can help modestly. In the ENS nose, saline spray and irrigations provide only brief moisture, and while useful for nasal hygiene to clear out thick secretions, repeated use can wash away the natural nasal mucosal barrier, leading to further drying. Some patients find a pulsatile irrigator helpful rather than the neti-pot. Patients commonly find they must use saline sparingly so as to avoid further drying. It is important to clean out the irrigator regularly so as to avoid contamination of the machine, which can contribute to more sinus infections.

Irrigation solution

Normal saline rinse, can be isotonic or hypertonic. Some patients use Ringer's Lactate solution instead, as they find it is easier on the mucosa than regular saline. Some patients also prefer Breathe-Ease® XL nasal irrigation formula.

Spray

Normal saline spray can be isotonic or hypertonic. Some patients find hypertonic sprays helpful in dislodging thick mucus. Spray should preferably be buffered. As with nasal irrigation, patient may prefer Ringer's Lactate, or hyaluronic acid based nasal spray that they can purchase or make themselves. Some patients also prefer Breathe-Ease® XL.

Emollients, Gels and other preparations

Sesame oil based emollients have a long history in treating nasal dryness. Mayo Clinic offers a sesame and rose geranium oil preparation. Ponaris nasal emollient is also well known, but is recommended with reservation because of its iodine content and possible adverse effects in thyroid sensitive populations. Petroleum-based emollients should be avoided. Other popular preparations include: Rinopanteina, Siccalix, Nozoil, and Premarin cream. Preservative free

products are preferable. Preparations should be selected with regard to their pulmonary effects.

There are many preparations for nasal dryness on the market. Selection should be made with reference to lung health. Dexpanthenol and hyaluronic acid based preparations are newer to the market. Related studies on dexpanthenol indicate its efficacy in the dry nose. [51] [52]

Irritation and burning are common adverse effects of emollients, gels, and other preparations. Some patients find emollients further decrease nasal sensation and in general all preparations can make nasal breathing more difficult.

Humidifiers

Warm mist or cool mist humidifiers are helpful. Travel or personal humidifiers are available.

Antibiotics

Mupirocin antibiotic ointment is recommended. Other antibiotic treatment may be indicated for severe infection or chronic sinusitis. Antibiotic nasal irrigations are indicated in advanced forms of ENS where *Klebsiella ozena* or other colonizing bacteria may be present. For management of chronic sinusitis in ENS patients see "Chronic sinusitis" in the section **Complications**.

Steroids

Studies on intranasal corticosteroids indicate that their safety [53]. However, their long-term effects on the mucosa of patients with ENS is not as clear. It is known that they can be damaging under certain circumstances. Temporary use of sprays and solutions added to saline irrigation for acute inflammation may be indicated.

Nasal airflow restriction

Nasal filters can be worn to restrict airflow and retain moisture. Sanispira brand nasal filters have been used by European ENS patients. Placing cotton in the nostrils or nasal cavity is not recommended because of possible aspiration.

Breathing

Menthol can improve nasal airflow sensation 54.Patients with significant dyspnea may see mild improvement with breathing retraining or speech therapy. More on breathing can be found in the section **Complications**, subsection **Anxiety and Depression**.

Sore throat

The throat may be dry and irritated as a result of surrounding dryness of nasopharynx and throat. Dryness and irritation can also be caused by nasal moisturizing preparations. Using a humidifier, remaining in a humid environment, and moisturizing nose with saline can improve dryness. Using a less irritating emollient and decreasing frequency of use of moisturizers may help. Loz-enges (especially mentholated which can temporarily improve nasal airflow sensation) can provide temporary relief. Hot teas, gargling, and vaporizers are helpful.

Dry mouth

The mouth may be mildly dry as a result of surrounding dryness of nasopharynx and throat. Dry mouth may be exacerbated by oral breathing. Dental issues may develop secondary to dry mouth. Products on the market designed for dry mouth are helpful. Drinking fluids is also helpful.

Surgical Treatment (Implantation)

Surgical treatment for ENS using implants is appropriate for patients who have experienced significant turbinate resections. This treatment can be helpful in improving breathing, but there are limitations, especially with respect to function such as humidification, regeneration, or immune protection of the original mucosa. Since implants do not recreate the original nasal structure and aerodynamics, they may provide only limited improvements for a patient even if implanting can be helpful in some patients, especially those with substantial resections.

The surgical goal of implantation is to recreate the shape of the removed turbinate and thus regain some of the nose's capabilities to adequately pressurize, streamline, heat, humidify, filter, and sense the airflow. The idea is to re-establish nasal resistance, increase mucosal surface area, and restore nasal aerodynamics [55].

Surgical method involves narrowing the airway to provide more nasal resistance and directing the airflow to untouched tissue and in a more physiological way — either by increasing the size of partially resected turbinates with implant material or by creating what are called neo or pseudo turbinates. This is accomplished through submucosal implantation of graft material. The location of an implant should ideally re-create the natural airflow patterns within the nose [56].

For patients who are ENS-IT, the implantation is placed in the nasal septum or floor mucosa, or lateral wall. For ENS-MT, the implantation is placed in the septum. For ENS-type, it can be placed submucosally in the residual turbinate [57].

Current implantation materials include: acellular dermal matrix (ADM), autograft (auricular and costal cartilage), and hydroxyapatite [58]. ADM may be used in its micronized form (e.g. Acell) and injected in the turbinate of patients with less severe volume deficit. Acell implants in combination with Adipose derived stem cells (ADSC) are being tried in certain centers.

Opinions differ on the length surgical treatment should be deferred - ranging from a few months to a year, in which time neural healing may take place [59] [60].

While not all patients (properly assessed candidates) will derive benefit from surgical intervention for ENS, it does appear to result in clinical improvement and a positive association with quality of Life (QOL) [61]. Evaluations were focused on improvement on the SNOT questionnaire. A systematic review of surgical interventions indicated that the average total SNOT score improved after surgery, with an average improvement of 29.0 (standard deviation, 15.9) points. In addition, at least 50% of patients reported an improvement of 30 SNOT points or more [62].The improvement needs to be clinically significant [63]. Long-term studies on clinical outcome beyond a follow-up period of 48 months are needed [64].

Complications may include: donor site morbidity, infection, extrusion, and resorption [65].

Experimental Treatment (Regenerative Medicine)

Experimental treatment includes a number of regenerative medicine based treatments. These include intra-turbinal or intranasal injections of various combinations of platelet-rich plasma (PRP), platelet rich lipotransfer (PRL), extracellular matrix (ECM), adipose derived stem cells (ADSC), stromal vascular fraction (SVF), and adipose tissue (fat grafts). A few practitioners (ENT & plastic surgeons) offer these treatments in the United States, Germany, Spain, and Italy with results in improvement of mucosal function and turbinate morphology. Differentiated (expanded) ADSC treatment is undergoing trial in China. Similar developments are occurring in South Korea and India [66] [67] [68] [69]. Duration of the positive effects of these treatments is unknown. For example, concerning fat grafts, the percentage of adipose tissue resorption and length of time the process takes in the turbinate has not been studied. Patients with larger resections may not benefit from fat grafts to the degree they might with conventional grafts if adequate turbinate volume cannot be created.

FURTHER ADVICE

Nasal valve collapse

Nasal valve collapse can be helped with Breathe-Right nasal strips and nasal cones. Tender noses from damaged nasal mucosa can make it difficult to use these products. Valve collapse can be evaluated by means of CT scan comparison and Cottle test, for example [70].

Further surgery

Further surgery should be weighed very carefully. Surgery to repair nasal valve or other structural collapse may complicate ENS. For example, nasal valve repair may widen the airway increasing airflow and further drying the mucosa. Septoplasty may also result in a widened airway having greater drying effects. Surgically induced nerve damage may have a negative effect with respect to lack of airflow sensation. Repairs to septal perforations can be considered since they may contribute to nasal dryness. Sinus surgery, if necessary, may be considered, but should be approached conservatively so as to preserve remaining turbinate tissue and nasal structures. Further turbinate surgeries are not recommended.

Surgery on adjacent areas to the nose that may further open the airway (e.g. palate, tonsils) should considered with regard to the possible negative effects on the ENS and breathing.

Environmental Limitations/Concerns

ENS patients experience an increase in symptoms in windy, dry, cold, hot, air-conditioned, or heated environments. For this reason, buildings with HVAC, and the outdoors pose potential difficulty for the ENS patient. In both indoor and outdoor environments, the addition of blowing air or windy conditions can quickly dry and irritate the mucosa. Particulate matter such as dust, household and food products in powder form, outdoor particulate such as yard refuse can penetrate unimpeded through the nasal cavity to the lungs causing choking and breathing difficulties. Thus, ENS patients may have environmental-related limitations. These limitations can affect the patient's daily activities, especially work, social, physical exercise, and general enjoyment of life. Since the nose can no longer respond normally to the environment, patients find they must locate or create an environment to suit their nose, and simply avoid difficult environments altogether, preferring to remain in their homes, where environmental conditions are able to be controlled.

Recommendations: Travel with portable humidifiers and a CPAP with a built-in humidifier. Apply emollients when needed to protect from the elements, heating and air conditioning. Cover the nose if all else fails.

Exercise

Aerobic (cardio) based exercise may be difficult because of patient breathing problems and may need to be approached in moderation or with light exercise. Strength training is a good alternative form of exercise. Swimming is popular among ENS patients.

Travel

Travelling may pose difficulties. Suggestions include portable humidifiers such as the personal warm mist humidifier MyPurMist (can be used with a car adaptor) and water bottle-based personal cool mist humidifiers (also can be used with a car adaptor).

COMPLICATIONS

Dry eyes

Dry eye and blepharitis can be treated by an ophthalmologist or dry eye specialist. Lid hygiene, compresses, and eye drops can lessen severity of dry eye and prevent recurrence of blepharitis. Keeping the nose moist can reduce the severity of dry eye.

Sleep

ENS patients experiencing sleep problems should be referred to a sleep specialist to have a sleep study performed. Many ENS patients have sleep-disordered breathing, including upper airway resistance syndrome (UARS), hypopnea, and apnea, including central sleep apnea. Sleep deprivation has a significant effect on the ability to learn, can have metabolic effects, impair memory. It can increase risk for development of type 2 diabetes and heart disease, and Alzheimer's disease. Using a humidifier when sleeping can assist with sleep. Some ENS patients find CPAPs with built-in humidifiers helpful. Medication may be necessary, but should be selected with regard to drying effects on the nasal and adjacent mucosa, which can worsen breathing and increase nasal and facial pain.

Pulmonary

ENS patients can be referred to pulmonology for treatment of asthma and other breathing-related concerns secondary to ENS [71]. Patients presenting with breathing difficulties should routinely be referred for pulmonary evaluation. Evaluation which reveals an ENS-related complication can then be treated in conjunction with a pulmonologist. ENS pulmonary complications have not yet been specifically studied, but literature on unified airway disease may be instructive.

Patients with acute dyspnea may benefit from breathing retraining or speech therapy. Medication can be considered, but the drying effects of the selected medication must be assessed. Moist environments can lessen cold-air hyperventilation-provoked bronchoconstriction and coughing induced by the patient inspiring cold, dry air [72]. Patients have reported that asthma medications are drying and can aggravate ENS symptoms.

Pain Management

Pain can include neuralgia and burning sensations, trigeminal nerve-related pain, and other facial and nasal pain. Patients with pain that is not alleviated or reduced through nasal moisturizing or by use of over-the-counter pain medications can be referred to pain medication specialists (algologists). How-

ever, alternative therapies should be tried before referral to pain management because of the risk of increasing nasal dryness and unwanted medication side-effects, especially if the patient is already being treated for other ENS complications with medication. Patients with pain related to the sphenopalatine ganglion may be improved with a nerve block [73].

Chronic Sinusitis

A subset of ENS patients may suffer from sinusitis. Some patients develop sinusitis as a complication of ENS. Impaired defense mechanisms of the nose contribute to chronic sinusitis [74].

Anxiety and Depression

Anxiety and depression are secondary symptoms that can occur as a result of ENS.

ENS patients commonly begin to experience symptoms of anxiety and depression secondary to the onset of ENS, having not had such symptoms prior to surgery. Anxiety can manifest as state of panic related to the patient's "fight-or-flight" response being triggered by breathing difficulties, primarily: paradoxical obstruction, lack of nasal airflow sensation, and disturbed nasal airflow pattern. Depression stems in large part from the fact that nasal function has been severely damaged and that there is no cure for ENS. Additionally, a decrease in quality of life, sleep deprivation, physical suffering, and a requirement for chronic nasal care play a substantial role. While there is some incidence of pre-existing anxiety and/or depression among a small subset of patients just as in any other condition, which can worsen symptoms, these pre-existing conditions do not play causal role in ENS. **Nasal breathing is an involuntary life-sustaining process, and, in the ENS patient, that process has been disrupted affecting physical and psychological regulation.**

Studies on surgical treatment for ENS indicate that there is improvement in anxiety and depression following successful surgical treatment. This suggests when the disease burden is reduced psychological symptoms improve or resolve [75] [76]. However, not all patients are able to achieve improvement with surgical treatment. Clinical improvement following surgical treatment depends upon the type and extent of damage in each individual patient, as well as other factors.

There are no specific studies on the incidence of anxiety and depression caused by ENS. Studies on the incidence of anxiety and depression in chronic illness may be relevant.

It is important to recognize the grieving process in anxiety and depression caused by an irreversible surgical complication (ENS). Grief focuses on the loss of a key sensory organ and impairment of a life-sustaining respiratory function. Other contributors to anxiety and depression include: lack of recognition and support from friends, family, and medical professionals; lack of available treatments; absence of insurance coverage for current treatments; inability to work due to severity of symptoms, stress from lack of income (e.g. some ENS patients end up homeless); difficulty obtaining disability.

Psychological support should include specialists who are familiar with treating patients with chronic illness (also breathing disorders and pain). If therapy is insufficient, a combination of counseling and medication may be warranted for optimal benefit. If treatment with medications is indicated, care must be taken to select medications that do not increase dryness and worsen ENS symptoms, especially nasal burning, pain, dryness, and tightness. However, most classes of psychotropic medication are drying. Benzodiazpines are without this side effect, but carry the risks of dependence and addiction and so are not a long term solution.

Relaxation techniques such as progressive muscle relaxation can have modest benefit, but those focused on breathing will be difficult for the ENS patient due to their difficulties with nasal breathing. Breathing retraining and diaphragmatic breathing can be helpful in assisting patients who have difficulty regulating breathing. Mouth breathing is not a reasonable alternative, it does not resolve ENS.

Compromised quality of breathing has a direct effect on nervous system function and other body systems [77].

Patient care should be coordinated with ENT, primary physicians, and other specialists in the event of complications.

PROGNOSIS

ENS is a disabling condition having a severe impact on quality of life. Conservative, non-surgical, treatment methods can produce mild to moderate improvement in some symptoms, but have little effect on the main, breathing-related, symptoms. Surgical treatment with implants can improve symptoms to a greater degree, including breathing-related symptoms. However, normal nasal physiology is not restored, and absent functional and structural features of the nose cannot be recreated. The patient may be left with significant impairment despite the degree of improvement produced by implantation.

While implants can certainly improve the lives of patients, they are not a cure for ENS. A substantial recovery or cure can be achieved by means of regenerative medicine, when nasal structures are restored both functionally and structurally. Patients are in urgent need for a cure.

PREVENTION

New diagnostics like CFD and computer simulation are suggested. They can be used to identify patients who may benefit from turbinate surgery and assist in surgical planning [78]. There is not really a reliable and objective means of selecting patients who will benefit [79].

Using conservative tissue sparing techniques, minimally invasive surgery with the goal to preserve mucosa are advised [80]. Damage to the overlying mucosa should be avoided, particularly as applies to cautery.

A number of studies have examined the various methods remarking on their safety and utility [81]. Submucosal reductions with a microdebrider, radiofrequency reduction or outfracture (lateralize) may reduce the risk of ENS by preserving the surface mucosa [82]. However, lack of evidence-level 2 studies on turbinate reduction, especially long-term studies, means that there may be no ideal technique that can be recommended [83]. Histopathological studies are needed to supplement studies focused on clinical efficacy. For example, a study on medium to long-term histopathological changes after coblation of the inferior turbinate, the long-term histological effects of reduction were found to be similar to those induced by laser.

These included: significant fibrosis, glandular and venous sinusoid depletion, a significantly decreased intact pseudostratified, ciliated, columnar respiratory epithelium, and a significantly increased partial epithelial shedding [84].

Turbinate reductions should not create excess dilation in what in the normal nose is a continuous uniform slit space. Normal respiratory function requires a sufficiently narrow flow channel, where there is physiological nasal airflow and adequate contact between the air and the mucosal surface [85] [86].

Contraindications include: aging mucosa which increases the risk of post-operative atrophic rhinitis [87].

Prior to surgery

Patient informed consent should include ENS as a risk associated with turbinate reduction, listing ENS as a rare, but possible complication.

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