

Review article

Evidence-based recommendations regarding the differential diagnosis and assessment of nasal congestion: using the new GRADE system

Nasal congestion is an important symptom in nasal pathology and can be defined as an objective restriction of nasal cavity airflow because of mucosal pathology and/or increased mucus secretion (excluding anatomical variants). Using the new Grading Recommendations Assessment, Development and Evaluation system, evidence-based recommendations are made that will encompass different clinical questions regarding diagnostic modalities of nasal congestion: (i) their usefulness in assessment of presence and severity of congestion; (ii) their usefulness in assessment of etiological pathology responsible for congestion; and (iii) their usefulness in follow up and treatment effectiveness evaluation of nasal congestion.

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As a common symptom of nasal pathology, nasal obstruction enjoys an increasing amount of interest from clinicians. Not without reason, as nasal obstruction is shown to correlate with a decreased quality of life and may lead to sequelae such as decreased sleep quality, rhinosinusitis, otitis media, and asthma (1). Perhaps because of the multitude of causes that can give rise to a subjective sensation or objective presence of nasal airway restriction many different synonyms are used in literature, apparently without a uniform definition. Common synonyms are nasal obstruction, nasal stuffiness, nasal congestion, and nasal blockage (2).

We can distinguish three general aetiologies: (i) objective restriction caused by mucosal thickening and increased mucus secretion, e.g. allergic- and nonallergic rhinitis and chronic rhinosinusitis (CRS) with or without nasal polyps; (ii) objective restriction caused by anatomical variants, e.g. septal deviation and perforation, nasal valve problems, and choanal atresia; and (iii) subjective feeling of insufficient airflow passing through the nose, despite adequate effort without an objective restriction, e.g. dry, atrophic nasal mucosa, septal perforation, postoperative state, or poor pulmonary function.

We define nasal congestion as follows: an objective restriction of nasal cavity airflow because of mucosal pathology and/or increased mucus secretion excluding

anatomical variants. This is in close concordance with the definition proposed by Corey et al. (1).

Physiology of nasal congestion

Nasal congestion, especially acute congestion is primarily the result of vascular phenomena (3), although plasma leakage and the influx of immunocompetent cells along with long-term remodelling of the nasal mucosa also may play a role. These phenomena are especially present in allergic rhinitis and CRS.

The nasal mucosa microvascular system is composed of both resistance and capacity blood vessels to facilitate normal mucosal defence and physiological functions of the nose (4). The capacitance vessels, venous sinusoids, are provided by resistance vessels, comprising small arteries, arterioles and arteriovenous anastomoses (5). Their volume is regulated by neural regulation, influenced by hormonal flux and affected by local mediators released from immunocompetent cells in the nasal mucosa (1, 6). A schematic of these regulatory processes is shown in Fig. 1. They are responsible for the 'nasal cycle', reflex-mediated effects (congestion caused by cold dry air) and the exercise-induced decrease in nasal airflow resistance (7–9). Pathological nasal congestion is likely to be the

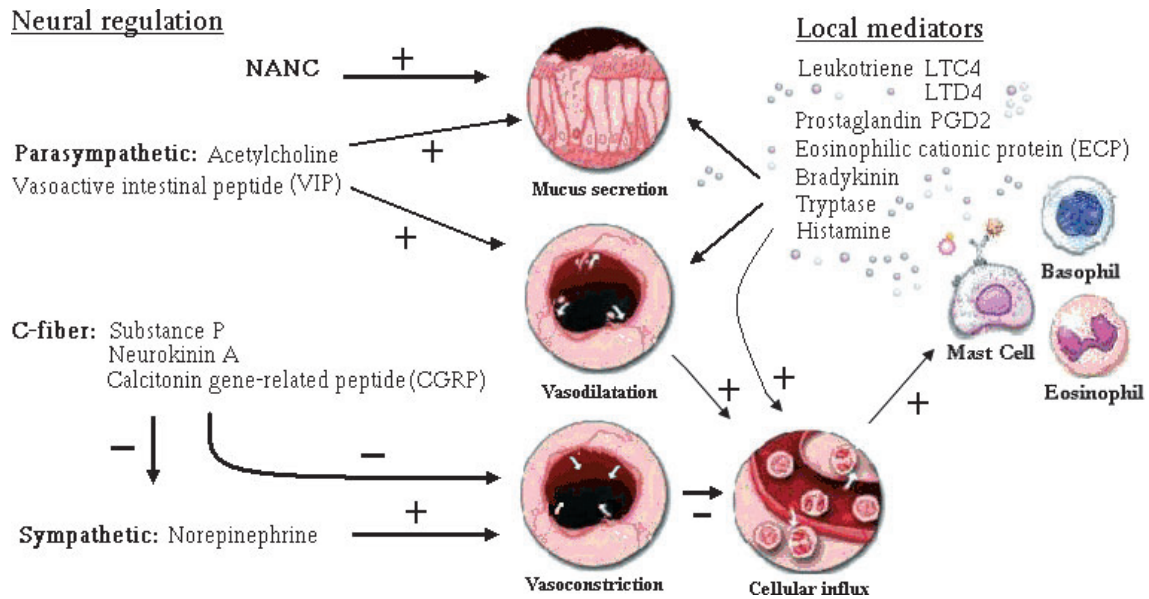


Figure 1. Processes of nasal congestion.

result of interaction between mediators produced by inflammatory cells and these mechanisms resulting in a deregulation of normal homeostasis. The fact that inflammation of nasal mucosa leads to hyperresponsiveness to normal physiological stimuli (10) would seem to support this view. Therefore, chronic inflammation because of cellular influx can be seen as propagator of sustained congestion, as seen in the 'late-phase' allergic response. An important marker of this response is the presence of eosinophils in the nasal mucosa. Many investigators have stressed their pivotal role within the inflammatory cascade. Eosinophils are also the most common inflammatory cells in nasal polyps, a common cause of severe nasal congestion.

Evidence-based medicine and guidelines

Guidelines are increasingly implemented in modern health care in the pursuit of achieving optimal treatment of diseases. They should be informative, simple, and easy to use to improve patient care. Evidence-based medicine (EBM) is an essential component in the preparation of guidelines (11, 12). It enables a systematic search, critical appraisal (for validity and usefulness), and incorporates information obtained from randomized controlled trials (RCT) in establishing clinical bases for diagnosis, prognosis, and therapy (13). However, most RCTs only study highly selected patients and are short from representing the entire population (selection bias), which implies that recommendations are not always applicable for the entire population (14). Physicians should therefore be wary of these limitations and always integrate recommendations in guidelines with their own clinical judgment, after

careful clinical evaluation and assessment of patient and disease factors (15). Even with its limitations, following guidelines has proven to be advantageous in the treatment of allergic rhinitis (16) and asthma (17), strengthening the rationale of implementing them.

Many schemes have been used to grade levels of evidence and the strength of recommendations (15, 18, 19). The new Grading Recommendations Assessment, Development, and Evaluation (GRADE) approach (20) is recommended by the WHO and is being increasingly applied by a number of organizations (21). It classifies recommendations into two levels; strong and weak and quality evidence into four levels; high, moderate, low, and very low (Table 1) (22). It has the unique ability of offering uniform evidence-based recommendations with regard to clinical questions, even in absence of high quality studies.

Summary of reviewed methods

There is a wide variety of diagnostic tools available to evaluate the symptom of nasal congestion. They include subjective and objective tools which do not always correlate with each other. Subjective tools reflect more accurately the patients perception of the complaint and its perceived severity, which should be a primary diagnostic consideration. This category comprises detailed history taking, symptom evaluation via scoring, nasal endoscopy.

Objective assessment tools are necessary, especially in research, as nasal airway restriction is difficult to quantify directly by clinical examination. Some of these methods are simple and easy to use whereas others require highly trained operators and relatively complex and expensive

Table 1. Grading recommendations (GRADE approach) modified from (18)

Grade of recommendation	Methodological quality of supporting evidence	Implications
1 A: Strong recommendation High-quality evidence	RCTs without important limitations or overwhelming evidence from observational studies	Can apply to most patients without reservations
B: Strong recommendation Moderate-quality evidence	RCTs with important limitations or exceptionally strong evidence from observational studies	Can apply to most patients without reservations
C: Strong recommendation Low-quality evidence or very low quality	Observational studies or case series	Can apply to most patients without reservations may change when higher quality evidence becomes available
2 A: Weak recommendation High-quality evidence	RCTs without important limitations or overwhelming evidence from observational studies	Best action may differ on circumstance or patients values
B: Weak recommendation Moderate-quality evidence	RCTs with important limitations or exceptionally strong evidence from observational studies	Best action may differ on circumstance or patients values
C: Weak recommendation Low quality evidence or very low quality	Observational studies or case series	Other alternatives may be equally reasonable

RCT, randomized controlled trial.

equipment limiting their usefulness in clinical practice. The methods and tools commonly used are nasal airway assessment, radiology, mucociliary clearance time, olfactory function, nasal nitric oxide (nNo) measurements, allergy testing and nasal allergen challenge, cytology and histology, specific haematology and microbiology culture.

Other less frequently used or 'experimental' methods will briefly be discussed without recommendations being made regarding them.

Summary of reviewed topics

This article will outline the level of evidence present and make recommendations regarding the usefulness of these evaluation methods and diagnostic tools in different clinical questions.

Nasal airway restriction is a common complaint which cannot be objectivated in all patients. Why some patients feel this sensation without objective abnormalities is not yet elucidated (23). One could speculate that nasal airflow plays a role (24). This is in concordance with the fact that patients have such sensations after laryngectomy (25). The resulting cessation of nasal air flow will lead to a 'stuffed' feeling even though nasal blood flow decreases (26), mucociliary clearance increases (27), and no apparent disease is present. It is therefore crucial to assess whether congestion is present and in which severity. Therefore, the following clinical question arises:

- The usefulness of various methods in assessment of the presence and severity of the nasal congestion.

A patient presenting with nasal congestion, when presence and severity has been assessed, needs to be diagnosed with an etiological cause. This results in the following question:

- The usefulness of various methods in search of an etiological diagnosis when there is a history of symptoms.

After assessment of presence and severity of nasal congestion and diagnosing the etiological cause, an effective treatment should be started. As a prerequisite of EBM, a useful parameter should be used in measuring treatment effectiveness. We therefore try to answer the last clinical question:

- The usefulness of the various methods in follow up and evaluation of treatment effectiveness.

Recommendations regarding the various diagnostic tools and evaluation methods.

Subjective methods

Medical history taking. Detailed patient history with physical examination is the foundation of patient diagnosis for nasal congestion. Concomitant symptoms like eye symptoms, sneezing, itchiness, smell, rhinorrhoea, fever, seasonal influences and medication used are helpful to diagnose the cause, especially to diagnose allergy and rhinosinusitis with or without nasal polyps. Distinction between unilateral and bilateral congestion is useful to exclude aetiologies like inverted papilloma, choanal polyp, foreign body reaction, rhinolith, hypertrophy of turbinate mucosa and malignancies, which normally present themselves unilaterally.

Other symptoms related with nasal congestion include sleep apnea, habitual snoring (28) and facial pressure. They could be related to symptom severity or with probable cause of congestion. However, the value of such relation is relatively small, as history taking is not a standardized method in evaluating severity. 'Physiological' nasal congestion should be regarded. The nasal cycle can result in a congestion which alternates in affected side or in a cyclic congestion one-sided (7). If congestion is present only in supine position, this could be the result of a volume increase of the inferior turbinate obstructing the inferior meatus. Forced nasal expiration, like in

frequently blowing the nose, can lead to a decrease in nasal patency possibly through neuronal pathways (29).

Airborne irritants can lead to nasal congestion and therefore careful history taking should be performed regarding smoking habits, passive smoking and air pollutants (30–32). Further examination of indoor air conditions and air-conditioning needs to be performed as they are presumed to be related with nasal congestion (33, 34). To exclude drug-induced rhinitis, a detailed history of medications used should be included. Rhinitis medicamentosa, a drug-induced, nonallergic form of rhinitis, is associated with prolonged use of topical vasoconstrictors, i.e. local decongestants, such as xylomethazoline and oxymethazoline. Rebound congestion occurs when the decongestive effect of the drug has disappeared. To alleviate this, patients start using larger doses of the vasoconstrictor more frequently. Careful questioning is required during consultation to establish diagnosis (35). Pregnancy has been correlated with nasal congestion as well (36–38). Rare disorders such as Wegener, sarcoidosis and cystic fibrosis should also be regarded. Especially when more frequent causes are absent. Perhaps because of the evident and obvious benefit in diagnosis, no trials (evidence) were found in literature to support this claim.

In diagnosing the cause of nasal congestion history taking is useful. (1C: strong recommendation, very low quality evidence)

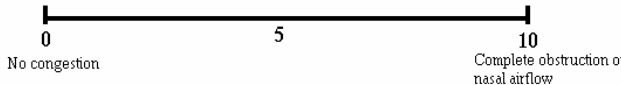
In follow up and assessment of treatment effects on nasal congestion, history taking is useful. (2C: weak recommendation, very low quality evidence)

Subjective evaluation of congestion. The primary diagnostic consideration is based on the perceived severity of the congestion complaint of the patient. Not surprisingly clinicians therefore value subjective severity assessment. Still, as was mentioned before, a perceived congestion does not always correlate with objective presence and mere history taking is not standardized.

Many validated questionnaires are developed to evaluate subjective nasal complaints and their impact on quality of life. The Rhinosinusitis outcome measurement (RSOM-31), sinonasal outcome test (SNOT-16, 20, 22) (39–41), sinonasal assessment questionnaire (SNAQ-11) (42) have been shown to be good and validated assessment tools in both clinical and research setting. It should be noted that SNOT 16 and 20 variants actually do not include nasal congestion as parameter and therefore are not suited for evaluation of this symptom. It has been suggested that we should regard the use of single questions out of validated questionnaires with some reservations.

Symptom ratings using four or 6-point Likert scales (Table 2) are often used as well. Although used in research setting (43), no validation of these ratings in nasal pathology could be found in literature. Results have suggested that every nose is 'individually calibrated', because of the interpatient variation, which makes

Table 2. Examples of subjective congestion scoring methods

Visual analogue scale: Place a marker with a pen to indicate the severity of nasal congestion 													
Symptom scoring (4 or 6 point scale): <table> <tr> <td>0: no congestion</td><td>0: no congestion</td></tr> <tr> <td>1: very mild congestion</td><td>1: mild congestion</td></tr> <tr> <td>2: mild congestion</td><td>2: moderate congestion</td></tr> <tr> <td>3: moderate congestion</td><td>3: severe congestion</td></tr> <tr> <td>4: severe congestion</td><td></td></tr> <tr> <td>5: very severe congestion</td><td></td></tr> </table>		0: no congestion	0: no congestion	1: very mild congestion	1: mild congestion	2: mild congestion	2: moderate congestion	3: moderate congestion	3: severe congestion	4: severe congestion		5: very severe congestion	
0: no congestion	0: no congestion												
1: very mild congestion	1: mild congestion												
2: mild congestion	2: moderate congestion												
3: moderate congestion	3: severe congestion												
4: severe congestion													
5: very severe congestion													

interpatient comparisons less reliable but still significant (44, 45).

Visual analogue scale (VAS) has also been used to determine symptom severity which seems to equal symptom scoring either by patient or physician, or both. The VAS method was proven to be a good and validated assessment tool of rhinitis (46) and postoperative result after endoscopic sinus surgery (47, 48). Nonetheless, overall outcome is not always correlated with individual symptom score validity (49), so caution in extrapolating these results is warranted. Further validation seems to be needed to determine to what extent the individual score relates to severity. For the symptom congestion alone no validation could be found in literature.

Questionnaires, VAS and the various symptom scoring systems are all capable of determining subjective changes in perceived congestion severity. Therapeutic intervention is always aimed at relieving subjective complaints and therefore subjective parameters are necessary.

Subjective score of congestion (VAS, symptom rating) is useful in evaluating presence of nasal congestion. (2C: weak recommendation, very low quality evidence)

Subjective score of congestion (VAS, symptom rating) is useful in evaluating severity of nasal congestion. (1C: strong recommendation, low quality evidence)

In follow up of, and assessment of treatment effects on, nasal congestion subjective symptom assessment is useful. (1B: strong recommendation, moderate quality evidence)

Physical examination (nasal endoscopy). Although subjective in nature, scoring, using standardized methods, performed by a physician using validated scales is regarded an objective measurement as the observer is not capable of scoring perceived symptom severity. Anterior rhinoscopy is limited in its evaluation of the

entire nasal cavity and therefore complete and thorough examination using nasal endoscopy is advocated (50). Rigid endoscopy has proven to be more patient friendly and supplies a better image than flexible endoscopy (51). Allergic and inflamed mucosa, pus in the middle meatus, consistency of nasal mucous and possible presence of nasal polyps should be evaluated. As nasal congestion can be caused by pathology in the nasopharyngeal space, it should be examined as well (52). It is also advisory to perform endoscopy before and after decongestion for better evaluation of nasal mucosal thickening.

Although the usefulness of nasal endoscopy in the evaluation of the nasal congestion is obvious, no clinical trails were found to support this statement. It was shown to be moderately sensitive and highly specific in predicting CT scanning results in patients with CRS (53). The Lund–Mackay system of scoring nasal endoscopy findings is the only system regarding mucosal thickening (edema). However, especially this finding showed only a mere moderate inter-observer agreement (54) in a single study. No other systems regarding rating/scaling or scoring system of mucosal thickening or edema were found. This is in sharp contrast with the number of validated systems that evaluate nasal polyposis presence and severity. Some of these have been reviewed elsewhere and shown to have a good reproducibility (55). However, they did not find a correlation between size of polyps and the subjective symptom of congestion (55, 56). This discrepancy between objective findings and subjective complaints make endoscopy less suitable for assessment of severity. Still, when polyposis is present, nasal endoscopy scoring is very useful in treatment evaluation (55).

To differentiate between various causes of congestion, physical examination seems obligatory. Diagnosing causes of nasal blockage is essential: septal deviation, choanal atresia, and nasal valve dysfunction are readily diagnosed with physical examination.

Septal deviation can be present even without the physical appearance of a 'crooked' nose. The nasal septum consists of bony and cartilaginous structures and extends into the nasal cavity over the entire length of the nasal cavity ending at the choanae where the nasopharyngeal space starts (Fig. 2). Clearly one can see that septal deviations, especially those located posterior, can only be diagnosed with nasal endoscopy which also applies for choanal atresia (50, 57). Nasal valve problems result in occlusion, caused by collapse, of the nostrils during forced or strong inspiration as a result of the Bernouille principle. A positive Cottle sign, increased subjective nasal airflow after supporting the nostrils, is indicative for nasal valve problems. Signs of inflammation and of systemic disease should be looked for and are sensitive in diagnosing rhinosinusitis. Although the usefulness of physical examination in the diagnosis of nasal polyposis is obvious, no clinical trails were found to support this statement.

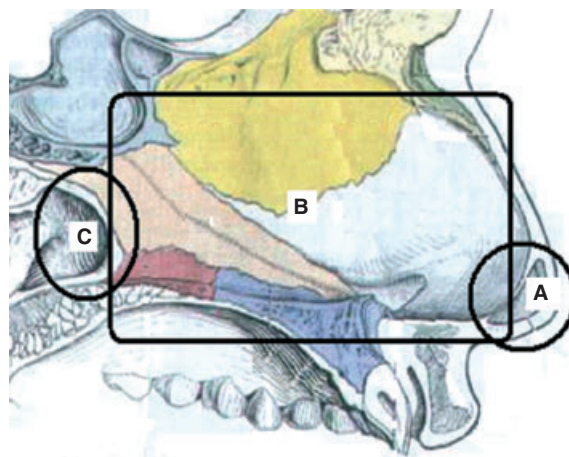


Figure 2. Localization of the different causes of nasal obstruction/blockage. (A) Nasal valve problems. (B) Septal deviations. (C) Choanal atresia. Figure edited from Moore, *Clinical Oriented Anatomy*, 3rd edition.

Nasal endoscopy is useful in evaluating presence of nasal congestion. (1C: strong recommendation, very low quality evidence)

Nasal endoscopy is useful in evaluating severity of nasal congestion. (2C: weak recommendation, very low quality evidence)

In diagnosis of etiological cause of nasal congestion physical examination is useful. (1C: strong recommendation, very low quality evidence)

In follow-up of and assessment of treatment effects on nasal congestion caused by nasal polyps, nasal endoscopy, is useful. (1A: strong recommendation, high-quality evidence)

Objective methods

Nasal airway assessment. Nasal airway assessment is typically performed by specialists. They are used in both research and clinical setting. Several tests are used in the assessment of the nasal airway. They include, among others, peak nasal inspiratory flow measurement (PNIF), rhinomanometry, and acoustic rhinometry.

PNIF measurement. Peak nasal inspiratory flow is an inexpensive, quick and easy test to estimate nasal airflow. It enables 'at home' measurements which can give insight into the complaints of patients, especially when compared to their perceived congestion noted in a diary (58). Any discrepancies between perceived severity and PNIF are easily determined this way, supplying relevant clinical information regarding the complaint. Normative results are known, although not all variables had been fully investigated (59). Nasal peak expiratory flow is a less useful measurement and therefore not recommended over inspiratory flow (60). Potential disadvantages such as that this method measures both sides together are mentioned

(61, 62). One could easily measure one side by occlusion of one nostril, yet such results have not been published, validated or correlated with perceived severity. Another limitation of this method is the interference of the nasal valve mechanisms. Because of the forced inspiration this technique requires, a possible collapse of the nasal valve would lead to a distorted result. Using devices to overcome this problem has been tried resulting in improvement of PNIF but no attempt at validation or correlation with perceived congestion was made (63).

Peak nasal inspiratory flow measurement has been used in several studies to determine nasal patency (64) with comparable sensitivity to acoustic rhinometry (65, 66) and rhinomanometry (61, 67, 68). A strong positive correlation has been described between PNIF and the subjective sensation of nasal obstruction determined by means of questionnaires (44, 69, 70). However, some have found no correlation with subjective complaints (68, 71) and some state that as a result of the great diurnal variability and poor repeatability, the test lacks the property of a good clinical test in primary care setting (72).

Rhinomanometry. Active anterior and posterior rhinomanometry, which is useful primarily as a research tool, is the simultaneous measurement of pressure encountered by nasal cavity airflow during the breathing cycle (73). Less accurate, but faster, is passive anterior rhinomanometry which is often used as outcome parameter of nasal provocation with allergens (73). Correlation has been described between rhinomanometry and the subjective sensation of nasal obstruction determined by means of questionnaires and VAS scores (74, 75). Some studies show corresponding results between rhinomanometry and subjective symptom scoring after inducing congestion or treating it, but no effort was made to correlate these findings with each other (76, 77). Only one study stated that the findings were not an exact match, i.e. not all objective improvements were reflected in improvement of subjective symptom scoring (77).

Acoustic rhinometry. Acoustic rhinometry is capable of measuring nasal obstruction by allowing the determination of the cross-sectional area of the nasal cavity as a function of the distance into the nasal cavity (78). It can be seen as a complementary test to rhinomanometry as they both assess different nasal attributes, nasal function and nasal geometry (79). Methodological aspects, variability of testing method and recommendations for technical specifications and standard operating procedures are outlined elsewhere (80–82). Acoustic rhinometry is, as a result of phenomena like the nasal cycle and the large inter-individual variations, less useful in determining if congestion is present. These characteristics are reflected in poor correlation between subjective symptom score and acoustic rhinometry in healthy subjects (83, 84) but not in congested subjects (84). The reference values in

adults and children have been investigated supplying proper normative data (85).

Rhinomanometry, PNIF, and acoustic rhinometry can be used in evaluating changes in nasal patency. In general it seems that subjective nasal obstruction correlates better with objective functional measurements of nasal airflow resistance (rhinomanometry, peak flow) than with measurements of nasal cavity width, such as acoustic rhinometry (86, 87). Despite noted variations, these methods are reliable parameters and are used in many studies as outcome of treatment effects.

Peak nasal inspiratory flow, acoustic rhinometry, and rhinomanometry are useful in evaluating presence of nasal congestion. (1B: strong recommendation, moderate quality evidence)

Peak nasal inspiratory flow and rhinomanometry are useful in evaluating severity of nasal congestion. (1B: strong recommendation, moderate quality evidence)

Acoustic rhinometry is useful in evaluating severity of nasal congestion. (2B: weak recommendation, moderate quality evidence)

In follow up of and assessment of treatment effects on nasal congestion nasal airway assessment is useful. (1A: strong recommendation, high quality evidence)

Radiology. Plain X-ray examination is an obsolete method because of its inability to individualize ethmoid and sphenoid disease and because of the insensitivity and limited usefulness in the diagnosis of rhinosinusitis as a result of the amount of false negative or positive results (88–90). Computed tomography (CT) has become the imaging modality of choice, especially preoperatively as it is capable of detailed imaging of the anatomy. Magnetic resonance imaging (MRI) is capable of making a distinction between soft tissues making it useful in diagnosis of different nasal pathologies.

A comprehensive CT scoring system often used is the Lund–Mackay score (91). Retest variability was shown to be small (92). Correlation between CT findings and total nasal symptom scores has been shown to be consistently poor and is not a good indicator of subjective nasal congestion severity (93–97). Nasal endoscopy was capable of making highly specific predictions whether CT abnormalities would be present in patients with CRS (98). Still CT scan and MRI findings have been shown to correlate with acoustic rhinometry findings in the assessment of cross-sectional areas within the nose (80) and with tissue eosinophilia (99). One should be aware that a possible correlation between CT findings and subjective complaint of nasal congestion alone has not been proven or disproved as no individual symptom outcome was given in mentioned studies and these studies only investigated patients with CRS. Chronic rhinosinusitis is often diagnosed by means of CT-scanning. Recent guidelines suggest that this is not necessary as diagnosing rhinosinusitis can be performed by history taking in combination with nasal endoscopy (98). Therefore, some

advocate that preoperative assessment is the only indication for performing CT imaging of the nose (100). Computed tomography scanning lacks the ability to distinguish between nasal mucosa and mucous. This hampers its usefulness in assessment of nasal congestion. Magnetic resonance imaging findings can be abnormal without any correlation with symptoms as was determined by using a modified Lund–Mackay scoring system. This is highly suggestive that MRI has no additional value in the evaluation of presence or severity of nasal congestion (101). No literature regarding correlations between MRI findings and subjective symptom scores was found. Magnetic resonance imaging is capable of making a distinction between nasal mucosa and mucous and is theoretically harmless when used repeatedly, its high costs and availability are making it a less useful tool as treatment outcome parameter. The used scoring system is validated but clinical importance seems lacking.

The role of CT scanning and MRI seems to be limited to preoperative assessment and in the staging and evaluation of tumours within the nasal cavity and paranasal sinuses.

Radiology is useful in evaluating presence of nasal congestion. (2B: weak recommendation, moderate quality evidence)

Radiology is NOT useful in evaluating severity of nasal congestion. (1B: strong recommendation, moderate quality evidence)

Radiology is NOT useful in diagnosing the cause of, and in follow up and assessment of treatment effects on nasal congestion. (2B: weak recommendation, moderate quality evidence)

Mucociliary clearance time. Mucociliary clearance time can be assessed using the saccharine test. This could give an indication of mucous viscosity and ciliary function which are affected by, or sometimes the cause of, nasal congestion.

Some studies have shown that during the normal physiological cycle, which gives rise to an alternating congestion and decongestion period, mucociliary function is decreased when congestion is present (102, 103). During pregnancy changes within the nasal mucosa result in an increase in subjective and objective nasal congestion parameters and a decrease in mucociliary clearance time (38). After radiation therapy of the nasal cavity, a decrease in clearance was found combined with an increase in nasal congestion sensation (104). During an induced common cold (rhinovirus infection) a decrease in clearing was found which corresponded with a decrease in objective nasal patency measurements (105). Unfortunately, the subjective complaints did not correlate with these findings. Using VAS scores, subjective complaints did decrease as did objective measurements in relation to an increase in clearance time (106). Some critical notes should be made regarding any causal relation. First increases in nasal airway patency was seen after successful

congestion treatment with a steroid without a significant increase in clearance time (107). Perhaps this can be explained as clearance could be affected by the steroid treatment or the aetiology studied (nasal polyps) has an inherent mucociliary impairment, however, saline sprays also improved the mucociliary clearance time without any objective effects on the rhinometric evaluation of the nasal cavity (108). Possibly the fact that control of mucociliary clearance is intimately related to autonomic activity (109) can provide a satisfactory explanation. As the modulation of vasodilation and vasoconstriction of the mucosal sinusoid system is also under autonomic control, one could hypothesize that when autonomic activity is modulated both clearance and mucosal congestion are affected. Yet when the viscosity of the nasal mucous is changed, this would only affect clearance times and not the capacity vessels.

Although significant differences in mucociliary clearance are found in relation with significant changes in congestion parameters, the findings did not always correlate with subjective/objective results of congestion and some studies doubted whether the results were even clinically relevant limiting its usefulness in clinical setting. Changes in mucous viscosity regardless of nasal congestion would influence outcomes. Other modalities seem to be better suited in follow up.

Mucociliary clearance is NOT useful in evaluating presence of nasal congestion. (2B: weak recommendation, moderate quality evidence)

Mucociliary clearance is NOT useful in evaluating severity of nasal congestion. (2B: weak recommendation, moderate quality evidence)

In follow up of and assessment of treatment effects on nasal congestion mucociliary function determination is NOT useful. (2B: weak recommendation, low quality evidence)

Olfactory testing. As airflow is hampered, one would hypothesize that olfactory function testing would be affected. Olfactory testing is possible in many different ways with their specific advantages and disadvantages. In general, two different methods of olfactory testing are described, i.e. electrophysical and psychophysical. In regular clinical use the psychophysical tests are applicable. These comprise of tests like the University of Pennsylvania smell identification test (UPSIT) and the Sniffin' sticks. For a detailed description of these tests and other olfactory modalities see elsewhere (110).

Nasal congestion has been found to be responsible for olfactory loss and even correlated to objective impairment of nasal patency (111). After treatment of congestion with a corticosteroid an improvement of olfaction was found possibly supporting this assumption (112). So one could think that the sense of smell is solely impaired because of nasal congestion. Yet, this conclusion is contradicted by even more studies in which no correlation was found between olfactory loss and objective nasal

airway assessment (113–117). These studies conclude that the underlying inflammatory processes are the true aetiology of the impairment of the sense of smell. This is also collaborated by the aforementioned study in which inflammatory processes are suppressed by steroid treatment. The normal physiological nasal cycle has no effect on olfaction although 'normal' congestion does occur (116). No further studies regarding a possible correlation between subjective congestion measurement and olfactory testing was found. So olfactory testing might serve as an outcome measurement in diagnosing possible inflammatory origin of nasal congestion. Yet, this has not been described in literature and other modalities are deemed more sensitive in assessing this.

Olfactory testing is useful in evaluating presence of nasal congestion. (2A: weak recommendation, high quality evidence).

Olfactory testing is useful in evaluating severity of nasal congestion. (2B: weak recommendation, moderate quality evidence)

In diagnosis of the cause of nasal congestion testing olfactory function is NOT useful. (1C: strong recommendation, low quality evidence)

Nasal nitric oxide measurement. The majority of nitric oxide is made in the sinuses (chest < 20 ppb, nose 400–900 ppb, sinuses 20–25 ppm) and therefore may be low even in the presence of normal activity if the sinus ostia are blocked e.g. nasal polyposis (118). The role of nNO as noninvasive marker of inflammation and as an outcome variable in allergic upper respiratory tract disease is therefore being debated in literature. Assessment of change in nNO is not very useful without information acquired through nasal endoscopy, as the cause of the change can be either inflammation-related or due to obstruction or opening of sinuses. Theoretically, nNO could be a marker of nasal congestion, as inhibition of NO synthesis relieved a leukotriene-induced nasal congestion in a guinea pig study (119). Another argument for the existence of a relation between nNO and nasal congestion can be found in the treatment of erectile dysfunctions with sildenafil. This drug enhances the effects of NO and leads to nasal congestion as a side-effect of this treatment (77).

A clear correlation has not been described and successful treatment of subjective symptom scores can be found without effects on nNO (120). No correlation between rhinomanometric evaluation and nNO was found (121) which is in contradiction with a relation between mucosal thickening and nNO levels. It was also shown that nasal polyps, a cause of nasal congestion, actually decrease nNO levels and successful treatment resulted in higher nNO (probably caused by opening the maxillary sinus ostium) and an improvement of subjective nasal congestion (118). Some state that the variance in test outcomes, lack of standardization and the lack of correlation with symptom scores make nNO measurement a less useful tool in clinical practice and research (122–124).

Although not very reliable as an inflammatory marker of upper airway inflammation, in nasal polyposis nNO measurement was used, as an outcome measure after therapy (125). If polyps block sinus ostia, a low concentration will be present. The concentration will rise when polyposis is effectively treated. An increase in inflammation could also show a rise in concentrations and therefore nasal endoscopy is needed to distinguish between these two possible causes.

Nasal nitric oxide measurement is NOT useful in evaluating presence or severity of nasal congestion (1B: strong recommendation, moderate quality evidence) NOT in the diagnosing the cause of, and in follow up and assessment of treatment effects on nasal congestion. (2B: weak recommendation, moderate quality evidence)

Allergy testing and nasal challenge with allergen. Allergic rhinitis is one of the most common causes of nasal congestion and has shown to enhance the nasal congestive reflexes (126). Patients with allergic rhinitis could not be separated from those with nonallergic rhinitis on basis of nasal congestion alone (127), making additional testing necessary. Perhaps that this statement is self-evident and testing modalities are easily available sporadic literature was found which proves that allergy testing is superior to history taking alone, especially regarding the diagnosis of house dust mite allergy (128). The skin prick test (SPT) and radioallergosorbent test (RAST) are commonly used and validated methods in allergy testing. In determining probable cause, allergy testing is a useful tool (129). However, SPT and RAST seem poorly or not at all correlated with allergic symptom severity and clinical relevance (130, 131). Although one study did show a slight significant correlation of the SPT with nasal congestion (132).

Nasal challenge with allergens is a method which, if performed in a standardized manner, is capable of determining presence of clinical relevant allergy and nasal congestion (133). The result of a nasal challenge can be assessed subjectively (symptom score or VAS) or objectively (by any form of rhinometry). Subjective symptom scoring after nasal provocation has shown to be correlated with patient quality of life (QoL) although not very accurately (134). Using nasal airway resistance (rhinomanometry) as an endpoint is less satisfactory because of the high intrinsic variation of these evaluations (135). The use of acoustic rhinometry to measure changes after provocation had given contradictory results (113, 135). One could debate the additional value of nasal challenge over allergy testing alone. One study found no significant impact of a positive house dust mite challenge on total rhinitis scores (136). As no additional value seems to be apparent, a weak recommendation to use it in differentiating etiologies is given. An exception must be made regarding occupational rhinitis in which provocation testing undoubtedly is very useful (137). Nasal challenge with allergen can be very useful in the

assessment of treatment success of allergy. One can clinically measure reactions to standardized doses of allergens with any subjective or objective outcome parameter assessment.

In diagnosis of etiological cause of nasal congestion allergy testing is useful. (1B: strong recommendation, moderate quality evidence)

In diagnosis of etiological cause of nasal congestion nasal provocation with allergens is NOT useful with exception of occupational rhinitis. (1B: strong recommendation, moderate quality evidence)

In follow up of and assessment of treatment effects on nasal congestion, due to allergic rhinitis, nasal challenge with allergen is useful. (2B: weak recommendation, low quality evidence)

Cytology and histology. Cytology can be acquired by means of nasal lavage, suction, smears, and swabs. Histology is possible when a nasal biopsy is taken. Although often used as tools in clinical research, these methods are not regularly used as diagnostic tools. As nasal congestion can be the result of inflammatory processes and cellular influx, one could hypothesize that these modalities might have good correlation with nasal congestion complaints. Eosinophils in nasal secretions have been investigated as a possible diagnostic tool in allergic rhinitis (138) as is their presence in nasal smears (139). No useful correlation was determined. No literature was found in which these modalities were validated as diagnostic tools in the assessment of nasal congestion. Still, presence of IL-10 in nasal mucosal cells seemed to correlate with symptoms, but not with congestion or PNIF results (140).

In diagnosing cause of nasal congestion nasal cytology and histology is NOT useful. (1B: strong recommendation, moderate quality evidence)

Specific haematology. In search of etiological causes of nasal congestion, blood analysis can be very useful in difficult or unusual cases. As vascular diseases, such as Wegener's granulomatosis, Churg Strauss syndrome, and microscopic polyangiitis regularly present themselves with nasal complaints (141–143) specific blood testing will reveal these diseases. Nasal congestion as sole complaint of primary presentation is rare, but cases are described (144–146). Another systemic disease which may give rise to nasal congestion is sarcoidosis (147). In difficult cases where no apparent cause can be found for nasal congestion, further investigation into these less frequent causes is warranted.

In diagnosis of etiological cause of nasal congestion specific haematology is useful in difficult cases. (2B: weak recommendation, low quality evidence)

Nasal microbiology culture. Nasal smears and swabs may assist in the identification of etiologic agents in infectious bacterial rhinosinusitis, which can be a cause of conges-

tion (148). In CRS, however, the role of bacteria is far from clear. A number of authors have described the microbiology of the middle meatus and sinuses. It was found that both anaerobic and aerobic species could be recovered from both diseased and nondiseased contralateral side of patients with CRS casting doubt on the aetiologic role of bacteria in CRS (149). As sole marker, it is unable to determine whether inflammation is the cause of congestion making it near useless in the etiological diagnosis of congestion. No literature collaborating this statement was found.

In diagnosis of etiological cause of nasal congestion nasal microbiology culture is NOT useful. (1B: strong recommendation, low quality evidence)

Other diagnostic tools and evaluation methods less commonly used

More diagnostic modalities are described in literature. We will briefly mention them as they have not (yet) found a place in common practice and research. Rhinohygmometry has been used in investigating the nasal cycle, but has been found to be less reliable than acoustic rhinometry (150).

Another method, rhinostereometry measures the horizontal range of the most anterior portion of the inferior turbinate (151–154). A good correlation between this method and acoustic rhinometry has been described (153) and it has been suggested to be a good and reliable method in objectively diagnosing nasal hyperreactivity (154). Laser Doppler flowmetry truly measures congestion as it reflects the state of the superficial vessels and not

Table 3. Recommendations

Recommendations made using the GRADE system:

	Presence	Severity	Etiology	Follow up
History taking	n/a	n/a	(+) strong	(+) weak
Subjective scoring				
VAS	(+) weak	(+) strong	n/a	(+) strong
Symptom scoring	(+) weak	(+) strong	n/a	(+) strong
Nasal endoscopy	(+) strong	(+) weak	(+) strong	(NP+) strong
Nasal airway assessment				
Rhinomanometry	(+) strong	(+) strong	n/a	(+) strong
PNIF	(+) strong	(+) strong	n/a	(+) strong
Acoustic rhinometry	(+) strong	(+) weak	n/a	(+) strong
Radiology	(+) weak	(-) strong	(-) weak	(-) weak
Mucociliary clearance	(-) weak	(-) weak	n/a	(-) weak
Olfactory function	(+) weak	(+) weak	(-) strong	n/a
nNO assessment	(-) strong	(-) strong	(-) strong	(-) weak
Allergy testing	n/a	n/a	(+) strong	n/a
Nasal provocation	n/a	n/a	(-) strong	(+) weak
Nasal cytology and histology	n/a	n/a	(-) strong	n/a
Microbiology culture	n/a	n/a	(+) weak	n/a
Specific haematology	n/a	n/a	(-) strong	n/a

(-), not useful; (+), useful; n/a, not regarded to be of any use in answering the clinical question;

(NP), regarding nasal polyps as etiology; VAS, visual analog scale; PNIF, peak nasal inspiratory flow; nNO, nasal nitric oxide.

the filling of the venous sinusoids (151). Trying to overcome the limitations of single observations, continuous measurement of nasal airflow using a portable rhinoflowmeter was introduced (155). It seemed a promising method in assessment of the phenomena of nasal congestion.

Increased blood flow through the nasal mucosa will result in measurable changes in nose temperature. Measuring these changes can be performed using infrared telethermography. Facial thermography is an objective, noninvasive method. Different locations have been investigated facial skin, nasal septum and conchal temperature (156–158). Nasal symptom scores seemed to correspond with thermography findings (156) and nasal provocation with allergen in grasspollen allergic patients also resulted in a higher nasal temperature (157). However, other variables like emotional changes, such as stress conditions have an influence on nasal temperature (159). Other variables that should be regarded when using this method are atmospheric temperature and the airway patency of

the ipsilateral nasal passage (158). The fact that many variables exist makes this method less useful.

Conclusion

We have provided recommendations regarding the differential diagnosis and assessment of nasal congestion (Table 3). The GRADE approach is capable of making recommendations regarding specific clinical questions, taking in account that in absence of high-quality evidence, still, strong recommendations can be given. It would seem that most methods discussed here need improved validation and their respective correlation with subjective complaints should be investigated. This would enable better comparison between studies regarding the same subject while using different outcome methods. These recommendations could form the basis of a guideline regarding diagnostic modalities regarding congestion.

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