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Original Research

ASTHMA

An Index to Objectively Score Supraglottic Abnormalities in Refractory Asthma

Learning, Validation, and Significance

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Background: **Patients with refractory asthma frequently have elements of laryngopharyngeal reflux (LPR) with potential aspiration contributing to their poor control. We previously reported on a supraglottic index (SGI) scoring system that helps in the evaluation of LPR with potential aspiration. However, to further the usefulness of this SGI scoring system for bronchoscopists, a teaching system was developed that included both interobserver and intraobserver reproducibility.**
Methods: **Five pulmonologists with expertise in fiber-optic bronchoscopy but novice to the SGI participated. A training system was developed that could be used via Internet interaction to make this learning technique widely available.**
Results: **By the final testing, there was excellent interreader agreement (κ of at least 0.81), thus documenting reproducibility in scoring the SGI. For the measure of intrareader consistency, one reader was arbitrarily selected to rescore the final test 4 weeks later and had a κ value of 0.93, with a 95% CI of 0.79 to 1.00.**
Conclusions: **In this study, we demonstrate that with an organized educational approach, bronchoscopists can develop skills to have highly reproducible assessment and scoring of supraglottic abnormalities. The SGI can be used to determine which patients need additional intervention to determine causes of LPR and gastroesophageal reflux. Identification of this problem in patients with refractory asthma allows for personal, individual directed therapy to improve asthma control.**
CHEST 2014; 145(3):486–491

Abbreviations: GER = gastroesophageal reflux; LPR = laryngopharyngeal reflux; RFS = reflux finding score; SGI = supraglottic index

Refractory[1] or severe asthma has a high associated morbidity and economic cost.[2,3] Even with asthma guideline therapy,[4] up to 50% of patients have asthma that is not well controlled or is refractory to treatment.[5] Fiber-optic bronchoscopy has been shown to be useful in evaluating both the upper and lower airways of patients with refractory asthma, which allows for better phenotyping of these individuals and, thus, specific patient-oriented therapy.[6] This approach has led to improved outcomes.[6]

Laryngopharyngeal reflux (LPR) can occur in association with gastroesophageal reflux (GER) or independent from GER. LPR can be injurious to the supraglottic area and lower airway, with potential aspiration. To better evaluate potential supraglottic injury resulting from LPR, a supraglottic index (SGI) was developed and used to give objective, applicable, and reproducible data for use in patients with asthma.[6] To

Manuscript received June 24, 2013; revision accepted October 7, 2013.
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Funding/Support: The authors have reported to *CHEST* that no funding was received for this study.
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DOI: 10.1378/chest.13-1455

keep consistency in that study, one individual scored the SGI. However, for clinical applicability, a teaching method for bronchoscopists to learn the SGI scoring technique was developed in concert with documentation that interobserver and intraobserver reproducibility was valid. This subsequent study demonstrates these points.

Materials and Methods

National Jewish Health's Institutional Review Board approval (HS2477 and HS2639) was obtained to use these prospective clinical data for publication. The SGI is a numeric scoring system that allows for an objective grading system to quantify the amount of supraglottic abnormality present. The purpose of this study was to determine if the five individual scorers could have reproducible results grading the same photos as the control reader.

Supraglottic Index

Three supraglottic structures (epiglottis, false cords, and arytenoids) are scored for the amount of edema (0 = none, 1 = mild, 2 = moderate, 3 = severe) that is present. In addition, these structures are evaluated for the amount of erythema or hyperemia by using the same numeric scale from 0 to 3. The posterior commissure (interarytenoid area) and the piriform recesses (piriform sinuses) are scored as normal = 0 or abnormal = 2. The score for the SGI ranges from 0 to 22 (Fig 1, scoring sheet).

Teaching Program

Five pulmonologists with expertise in fiber-optic bronchoscopy, but novice to the SGI, were recruited for this study. All five were trained in bronchoscopy using American Board of Internal Medicine guidelines and were board certified in pulmonary medicine. Three pulmonologists recently completed their pulmonary fellowships. One of the two senior pulmonologists was recruited from private practice; the other had a 35-year academic career. We believed that learning this technique would require multiple sessions before interobserver and intraobserver validity would be meaningful. Prior to the first scoring session, a 1-h training lecture with the use of photographs and video recordings occurred. During this session, the supraglottic index was described in detail, and each of the anatomic areas to be graded was reviewed. Examples of normal, mild, moderate, and severe edema and erythema/hyperemia for the epiglottis, false cords, and arytenoids were provided. Photographs of normal and abnormal posterior commissures and piriform recesses were also reviewed. Five cases were provided, and each physician graded them and compared their scores with the control reader.

Scoring session 1 consisted of 50 patients with four photographs each of the supraglottic areas; these were provided to the readers on a flash drive. Readers had the ability to adjust the photographic size using the zoom application on their computer. Figure 2 demonstrates an example of photographs used in grading the SGI. In this patient, the epiglottis received a score of 1 for edema and 1 for hyperemia; the false cords: 2 for edema and 3 for hyperemia; the arytenoids: 3 for edema and 3 for erythema; the posterior commissure: 2; and the piriform recess: 2. The sum of these makes an SGI score of 17. It should be noted that the true cords can be involved in patients with refractory asthma, but this is not part of our scoring system. After session 1 scoring, the readers were given the control reader's calculations so scores could be compared and discussed.

Session 2 consisted of the photos used in session 1 being randomly shuffled, and the physicians again calculated the SGI for 50 patients. Scores were reviewed, and readers again had reference to the control reader's SGI values.

In session 3, a new set of 50 different patients' supraglottic photographs were reviewed. These scores were compared with the control score. Readers were asked to rescore those SGI calculations that varied by four or more from the control reader. In addition, readers were asked to rescore if they had an SGI $\geq$ 10 and control $<$ 10 or SGI $<$ 10 and control $>$ 10. The reason for using the SGI cut point of 10 is that an SGI $\geq$ 10 was shown in a previous study to be a threshold value for the presence of LPR.[6]

Session 4 consisted of the photographs in session 3 being randomly shuffled and rescored. Individual scores were discussed and reviewed by the control reader with the other readers. Special attention was given to scores that varied by four or more points from the control reader and those discordant with the control SGI value of 10.

Interreader and Intrareader Validity

After the previously described sessions, 30 new patient photographs of the supraglottic area were distributed to the five learners. The distribution of SGI scores was 0 to 9 (nine patients), 10 to 16 (13 patients), and 17 to 22 (eight patients).

We assessed the relationship between scores for each novice reader and the control reader using a form of regression that can account for measurement error in the X variable (the scores of the control reader).[7,8] We conducted these analyses using R.[9] Using an SGI cutoff of 10 units,[6] we estimated κ between each new reader and the control reader (SAS/STAT software package, version 9.2 of the SAS System for Windows XP; SAS Institute Inc). We defined the critical significance level α to be 0.05.

Results

After session 1, there was expected variability among all naive readers compared with the control reader (regression $R^2 = 51\%$; range, 35%-65%). Figure 3A demonstrates the comparison of the naive readers vs the control reader of session 1 for SGI scoring. In the final scoring session, there was a marked decrease in variability between the naive readers and the control reader (regression $R^2 = 86\%$; range, 75%-92%) (Fig 3B).

Table 1 demonstrates the estimate of the amount of fixed (intercept) and proportional (slope) bias at the final testing session. A perfect SGI scoring between each naive reader and control reader would be represented by an intercept of zero and a slope of 1. If the CI for the intercept includes zero, the intercept is consistent with zero. If the CI for the slope includes 1, then the intercept is consistent with 1. For naive readers C through E, both the fixed and proportional biases are tightly linked to the control reader. A and B are acceptably linked to the control reader, with A overall reading slightly under the reader by 3.5 units and B slightly over by 2 units.

Additionally, for the final scoring for SGI $<$ 10 and $\geq$ 10, the interreader agreement of the SGI with the control reader is exceptional (defined as κ of