A Comparison of Initial and Subsequent Follow-Up Strobovideolaryngoscopic Examinations in Singers.

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A Comparison of Initial and Subsequent Follow-Up Strobovideolaryngoscopic Examinations in Singers

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Summary: Objectives. Previous studies have identified abnormal findings in up to 86.1% of singers on initial screening strobovideolaryngoscopy (SVL) examinations. No studies have compared the prevalence of abnormalities in singers on their subsequent follow-up SVL. Our study evaluates the frequency of these findings in both the initial and subsequent examinations.

Methods. Retrospective charts and SVL reports were reviewed on students from an opera conservatory from 1993 to 2014. All students had initial screening SVL, but only students who later returned with acute voice complaints were included in the study ($n = 51$, 137 follow-up visits). Normal SVL was defined as an examination without structural or functional abnormalities and reflux finding score ≤ 7. Data were analyzed using the chi-square test.

Results. For initial examinations, 90.2% (including reflux) and 88.2% (excluding reflux) were abnormal. In follow-up examinations, 94.9% (including reflux) and 94.2% (excluding reflux) had abnormal findings, which included muscle tension dysphonia (40.1%), vocal fold (VF) masses (unilateral 48.9%, bilateral 30.7%), vascular abnormalities (unilateral 27.0%, bilateral 5.8%), sulcus (unilateral 17.5%, bilateral 5.1%), VF hypomobility (unilateral 36.3%, bilateral 5.9%), phase (30.6%) and amplitude (44.8%) asymmetries, and glottic insufficiency (49.3%). Follow-up examinations revealed a significant increase in laryngopharyngeal reflux ($\chi^2 = 7.043$; $P < 0.05$).

Conclusions. We found a higher prevalence of abnormal findings compared with previous studies, which we attributed to a more inclusive definition of abnormal pathologies, improvements in SVL technology, and possibly increased experience with SVL interpretation. This high prevalence of abnormal findings in asymptomatic singers further supports the importance of baseline examinations.

Key Words: Voice abnormalities in singers–Voice pathology in asymptomatic singers–Dysphonia–Stroboscopy–Strobovideolaryngoscopy.

INTRODUCTION

Strobovideolaryngoscopy (SVL) is an invaluable tool for the evaluation of voice disorders.[1–3] The use of stroboscopic light dates back to 1878, and now, it is used widely by laryngologists to perform a detailed examination of the vocal fold (VF) movement and pathology.[1,2] SVL is a clinically useful procedure that can influence the diagnosis and treatment of patients. In studies by Sataloff et al, SVL modified the diagnoses in 47% of patients and confirmed uncertain diagnoses in many of the patients studied.[1,2]

However, when performing SVL, it is important to consider the degree to which abnormal findings contribute to a complaint of acute dysphonia. Previous studies of healthy singers demonstrated that, although there was a high prevalence of laryngeal abnormalities, many of these findings did not affect the singers' vocal performance.[3–5] In a study by Elias et al,[3] 58% of asymptomatic opera students ($n = 65$) had abnormal laryngeal findings including six clinical pathologies: reflux laryngitis, nodule, cyst, varicosity, VF asymmetry, and VF weakness. Lundy et al[4] studied 65 asymptomatic singing students, 57 with sufficient data to review, and reported the following incidences of abnormal findings: 5 (8.8%) with benign vocal lesions, 35 (61.4%) with posterior erythema, 17 (29.8%) with edema, and 20 (38.5%) with incomplete glottic closure. Sataloff et al[5] also reported abnormal SVL findings in 86.1% of asymptomatic singing teachers. Reulbach et al[6] studied occult laryngeal findings in asymptomatic adults (not singers) older than 40 years, and only 12% had normal laryngeal examinations.

Baseline examinations in professional voice users may provide a clinically important reference point when acute symptoms occur. Although previous studies documented abnormal findings in asymptomatic singers, they did not investigate the presence of these or other abnormalities on follow-up examination when acute symptoms occurred. Our study explored the differences in the prevalence of abnormal laryngeal findings in advanced singing students comparing their initial, routine evaluation and subsequent SVL examinations when acute dysphonia was present.

MATERIALS AND METHODS

A retrospective chart review was approved by the institutional review board at Drexel University College of Medicine. Our subjects were from an elite opera conservatory at which promising young singers are selected to attend the school on full scholarship. All new opera students from this vocal academy have a screening SVL performed at our voice center at the beginning of their freshman year. These students are referred back to our practice if they develop acute vocal complaints.

Demographic data and SVL reports were reviewed on all students from 1993 to 2014. Reports of the initial screening

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SVL examinations and of any follow-up examinations that were conducted for acute vocal complaints were reviewed. Freshman students from this cohort received baseline examinations during the study period; however, only 51 of them had follow-up visits to our office for voice complaints. Therefore, students with baseline examinations but no follow-up visits were excluded.

All SVL examinations were performed with the students in seated position, with or without the administration of oral topical anesthetic. The laryngeal observations were made using a KayPENTAX digital stroboscopy system (Montvale, NJ). The PENTAX distal-chip flexible nasolaryngoscope with continuous light and stroboscopic light is used routinely, as well as the Kay-70° rigid laryngoscope with stroboscopic light. Before the distal-chip laryngoscope was available, examinations were performed using an Olympus ENF-L3 flexible nasolaryngoscope (Center Valley, PA). The patient was asked to perform speech and nonspeech tasks to detect laryngeal abnormalities. Repetitive phonatory tasks (RPTs) and glissando singing maneuvers were used to detect neuromuscular abnormalities.[5,7] Stroboscopic light at different intensities and frequencies during phonation of /i/ was used to assess glottic competence, masses, structural lesions, vibratory patterns, and mucosal wave.[5,7] The SVL examinations were performed by laryngologists and laryngology fellows, and examinations performed by a laryngology fellow were contemporaneously reviewed by the senior author (R.T.S.).

Our study defined a normal SVL as having a reflux finding score (RFS) of $\leq$7 and an examination without structural or functional abnormalities. An RFS >7 is suggestive of laryngopharyngeal reflux (LPR).[8] Structural and functional abnormalities observed included muscle tension dysphonia (MTD), incomplete glottic closure, asymmetry of amplitude, asymmetry of phase, unilateral or bilateral VF hypomobility, unilateral or bilateral VF mass (cyst, pseudocyst, nodule, polyp, others), unilateral or bilateral VF tear, unilateral or bilateral VF vascular abnormality (ectasia, varicosity, or hemorrhage), and unilateral or bilateral sulcus (vocalis and vergeture). The diagnosis of MTD was based on stroboscopic findings as described by Morrison et al[9]: increased laryngeal muscle tension, abnormal glottal closure, and excessive supraglottic activity. Increased muscle tension can occur in the external and/or internal laryngeal musculature and can be identified by neck palpation. Different staging systems have been developed for MTD, including the Koufman and Blalock classification[10]; however, none are universally accepted. As a result, no classification system was used for MTD in our study.

Statistical analysis was performed using Excel 2010 (Microsoft, Inc., Redmond, WA), and descriptive statistics were calculated. Chi-square test (χ^2) was performed to analyze the number of abnormal findings in the initial and subsequent symptomatic examinations.[11] All the subsequent examinations (ie, second, third, fourth, etc) that were performed when the patient had acute dysphonia were grouped together to compare with the initial asymptomatic examinations. The degree of freedom for each comparison was one; thus, any χ^2 value greater than 3.841 was considered significant with an *a priori* probability level set at 0.05.

RESULTS

The charts of 51 students (age 26 ± 3 years, male/female 28/23) with a total of 188 SVL reports were reviewed. Table 1 summarizes demographic data of the study population. There were a total of 137 subsequent examinations. The average number of follow-up examinations per subject was 2.69 ± 2.24, and the median time between the initial and subsequent examinations was 266 days with interquartile range of 60 days to 615 days.

The most common abnormal finding was LPR with 69.0% of students presenting with this pathology at the time of their initial SVL examination and 90.3% during the subsequent examinations (Table 2). LPR was also the only pathology that was increased significantly between the initial and follow-up examinations with χ^2 of 7.043 ($P < 0.05$). The least common finding for the students during the initial examination was the presence of VF tear (3.9% for unilateral VF tear and 2.0% for bilateral tear). On the initial examination, 90.2% of students had one or more abnormal findings. Subsequent examinations revealed that 94.9% of the students had one or more abnormal findings, which was not significantly different from the initial examination. Excluding LPR, 88.2% of the students at the time of their initial examinations, and 94.2% of the students during their subsequent examinations, had at least one abnormal finding. Abnormal findings in the subsequent examinations included MTD (40.1%), VF masses (unilateral 48.9%, bilateral 30.7%), VF vascular abnormalities (unilateral

TABLE 1.
Demographic Data of the Study Population

Age at first examination (y)	
Mean ± standard deviation	26 ± 3
Range (minimum–maximum)	19–32
Male/female	28/23
Number of years of singing experience at first examination	
Mean ± standard deviation	9.7 ± 3.2
Range (minimum–maximum)	5–14
Voice types	
Soprano	13
Mezzo/mezzo-soprano	10
Tenor	15
Baritone	8
Bass-baritone	2
Bass	3
Duration of time between initial and subsequent examinations	
Median (interquartile range) days	266 (60–615)
Number of examinations per patient	
One (initial examination)	51
Two	51
Three	31
Four	20
Five or more	35

Note: All the patients were opera students at an elite opera conservatory. A total of 51 students who had 137 follow-up visit for a total of 188 strobovideolaryngoscopy examinations.

TABLE 2.
Comparison of Abnormal Findings in Singers' Initial and Subsequent Strobovideolaryngoscopies With Frequencies of the Abnormalities

Abnormal Findings	Initial SVL	Subsequent SVL	χ^2
Muscle tension dysphonia	25/51 (49.0%)	55/137 (40.1%)	1.197
Unilateral vocal fold hypomobility	16/51 (31.4%)	49/135 (36.3%)	0.395
Bilateral vocal fold hypomobility	3/51 (5.9%)	8/135 (5.9%)	0.000
Unilateral vocal fold mass	25/51 (49.0%)	67/137 (48.9%)	0.000
Bilateral vocal fold mass	15/51 (29.4%)	42/137 (30.7%)	0.027
Unilateral sulcus	5/51 (9.8%)	24/137 (17.5%)	1.695
Bilateral sulcus	2/51 (3.9%)	7/137 (5.1%)	0.115
Unilateral vascular abnormalities	14/51 (27.5%)	37/137 (27.0%)	0.004
Bilateral vascular abnormalities	2/51 (3.9%)	8/137 (5.8%)	0.271
Unilateral vocal fold tear	2/51 (3.9%)	10/137 (7.3%)	0.710
Bilateral vocal fold tear	1/51 (2.0%)	4/137 (2.9%)	0.132
Amplitude asymmetry	18/50 (36.0%)	60/134 (44.8%)	1.148
Phase asymmetry	13/50 (26.0%)	41/134 (30.6%)	0.371
Incomplete glottic closure	23/50 (46.0%)	67/136 (49.3%)	0.156
Reflux laryngitis (RFS >7)	20/29 (69.0%)	65/72 (90.3%)	7.043*
At least one abnormal findings with reflux pathology	46/51 (90.2%)	130/137 (94.9%)	1.371
At least one abnormal findings without reflux pathology	45/51 (88.2%)	129/137 (94.2%)	1.893

Note: Chi-square test (χ^2) was used to identify any differences in abnormal findings between these two examinations.
*Significant $P < 0.05$.

27.0%, bilateral 5.8%), sulcus (unilateral 17.5%, bilateral 5.1%), VF hypomobility (unilateral 36.3%, bilateral 5.9%), phase asymmetry (30.6%), amplitude asymmetry (44.8%), and glottic insufficiency (49.3%).

DISCUSSION

The importance of SVL in the evaluation of voice patients is well established. Previous studies have shown that SVL alters treatment decisions in 14–33% of patients.[1,2,12] In two studies, Sataloff et al[1,2] reported that stroboscopic information influenced the diagnosis and management of laryngeal abnormalities and voice complaints in 31.2% and 32.5% of patients. Casiano et al[12] reported that SVL altered the primary diagnosis and treatment outcomes in 14% of voice patients when compared with indirect laryngoscopy. More recently, Paul et al[13] quantified the diagnostic accuracy of history and physical examination, laryngoscopy, and stroboscopy in the evaluation of a dysphonic patient. The diagnostic accuracy of history and physical examination alone was only 5%. The diagnostic accuracy increased dramatically to 68.3% when laryngoscopy and stroboscopy were added.

Although SVL can provide important clinical information, a high prevalence of abnormal SVL findings (58–86.1%) in asymptomatic singers has been reported in multiple studies.[3–5] Our study confirmed these previous studies. On the initial SVL examinations, 90.2% of the asymptomatic operatic students had at least one abnormal finding. The prevalence of abnormal findings in follow-up examination was slightly higher (94.9%), but this was not statistically significant. This high prevalence of abnormal SVL findings confirms the importance of baseline examinations. Knowledge of existing pathologies in asymptomatic singers can help guide diagnosis and treatment when the singers present later with acute voice complaints; and identification of laryngeal abnormalities allows early intervention to help prevent permanent laryngeal injury. This information also provides singers with knowledge to optimize their vocal health and prevent unnecessary interventions when they have to seek medical care while traveling.

The prevalence of abnormal findings in our population was higher than that reported previously. This may be explained by a more inclusive definition of abnormality. Our study focused on 10 abnormalities (Table 2), whereas Elias et al[3] defined six entities as abnormal: reflux laryngitis, nodules, cyst, varicosity, and asymmetry. Lundy et al[4] also defined six entities as abnormal: masses, erythema, edema, glottic closure, mucosal wave, and amplitude of vibration. A previous study by Sataloff et al[5] on asymptomatic singing teachers defined nine abnormal entities: arytenoid erythema/edema, posterior hypertrophy, incomplete glottic closure, RFS $\geq$7, varicosities and ectasias, structural abnormalities, paresis, phase symmetry, and vibratory function.

Experience in interpretation of more than 30 000 SVL over 30 years also may have increased our sensitivity in detecting subtle abnormalities. As a result, more abnormalities may have been detected in recent years in comparison to the past. Elias et al's study was published from the same center and with the same senior author (R.T.S.) as the present study.[3] Elias et al studied asymptomatic singers from the same opera conservatory from 1985 to 1993. Our present study is a continuation of our center's experience with these opera students from 1993 to 2014. Elias et al[3] reported that 58% had abnormal SVL findings, whereas our present study reported 90.2% of abnormal

SVL findings on initial examination. Sataloff et al[1] reported a similar phenomenon in their study on the clinical value of SVL. They compared their SVL experience from 1985 to the calendar year of 1989 to determine whether additional experience had altered the clinical usefulness of the procedure. In the earlier period, SVL information influenced diagnosis or treatment in approximately one-third of the examinations. In the later period, the procedure modified diagnoses in 47% of examinations.[1,2]

Improvements in imaging technologies also may explain this increase. One of these recent improvements is the development of distal-chip technology.[14–17] This technology allows the camera lens of the charged coupled device to be miniaturized and inserted at the distal end of the flexible laryngoscope. The image degradation that occurs in a traditional fiberoptic scope through the course of the optical fibers is eliminated. This advanced technology produces superior images compared with the traditional nasolaryngoscope.[14–17] We used rigid laryngoscopes and flexible laryngoscopes in our study population. The Elias et al's study used rigid laryngoscopes and fiberoptic flexible nasolaryngoscopes without distal-chip technology.[3] Lundy et al's study reported using rigid laryngoscopes only[4]; and in Sataloff et al's study on asymptomatic singing teachers, only rigid laryngoscopes were used.[5] The Reulbach et al's study reported use of only flexible fiberoptic laryngoscopy.[6] We hypothesized that the combination of techniques used in our study might have increased our diagnostic sensitivity.

Transoral rigid and transnasal flexible SVL examinations each have strengths and weaknesses for detecting different abnormalities. Transoral rigid SVL has been shown to be superior for diagnosing VF lesions.[16,18] The images have little distortion and color misrepresentation, allowing for a more detailed examination of the vibratory margin of the VFs. Rigid SVL, however, is a more difficult examination to tolerate for children or patients with strong gag reflexes.[16] Transnasal flexible SVL allows for a better neurolaryngologic examination of the VFs. Dynamic voice analysis and connected speech can be evaluated with a transnasal flexible SVL, but such assessment is limited with a rigid endoscopic examination.[16] A flexible examination is tolerated by almost every patient. There are, however, optical limitations to some flexible scopes that can cause image distortions such as barreling,[16] and the inferior magnification and image resolution (compared with rigid examinations) may cause some abnormalities to go undetected.

Eller et al[16] evaluated the usefulness of fiberoptic and distal-chip flexible imaging technologies for the diagnosis of true VF pathology when compared with the gold standard of rigid transoral SVL. They reported that the ability to diagnose true vocal lesions was statistically equivalent with fiberoptic and distal-chip technology. Rigid SVL provided more information in 27% compared with the flexible fiberoptic examinations and in 32% compared with the distal-chip flexible examinations. Eller et al[17] performed a follow-up study in which they examined the usefulness of fiberoptic and distal-chip flexible imaging technologies for the diagnosis of LPR when compared with the gold standard of rigid transoral SVL. They concluded that both flexible systems underestimated the physical findings of LPR (such as posterior erythema) when compared with the rigid examination. Readers should be aware of the different technologies used in various studies and the strengths and weakness of each technique.

In our practice, the standard initial examination includes both a transnasal distal-chip flexible SVL and a transoral rigid SVL. Our protocol also has evolved to include extended RPT to diagnosis neuromuscular abnormalities which have been shown to correlate with subtle paresis.[19] Using this technique, our detection of VF hypomobility was likely higher compared with previous studies.

The incidence of LPR in our opera students' initial SVL (69.0%) was higher than that seen previously in the study by Elias et al[3] (42%) which examined a similar cohort. The prevalence of LPR reported in the literature is variable. Sataloff et al[5] reported that 18.1% of asymptomatic singing teachers had RFS $\geq$7, but if traditional physical findings were used to diagnose LPR (such as arytenoid erythema and/or edema), the incidence increased to 72%. Reulbach et al[6] reported that 64% of patients who had no reflux symptoms had LPR. Lundy et al[4] reported that 73.4% of asymptomatic singing students had posterior erythema, which commonly is a sign of LPR. Milstein et al[20] reported that at least one sign of LPR was detected in most asymptomatic subjects using flexible and rigid videostroboscopes. Another study found that 23.9% of healthy volunteer patients had RFS >7, but at least one mucosal sign of LPR was detected in 64–93% of healthy subjects.[21] This variation in the literature highlights that there is still debate over the best method to diagnose LPR, as well as the criteria on which the diagnosis should be made.[22] The RFS was introduced as a validated tool for the interpretation of LPR signs; however, controversy persists about its validity.[5] It remains unclear whether the true incidence of LPR is estimated best by the presence of any definitive physical signs on laryngoscopy or only findings severe enough to cause an abnormal RFS. This question provides an opportunity for future research.

Regardless of the debate over the correct method for diagnosing LPR, singers are more likely to report LPR symptoms when compared with the general population and to other professional voice users, such as teachers.[23–25] This is evidenced by a higher reflux symptom index score in singers.[23] Opera singers also report a higher prevalence of reflux symptoms such as regurgitation and heartburn compared with the general population.[24,25] Elias et al[3] hypothesized that the high prevalence of LPR in singers might be due to increased abdominal pressure from proper "breath support" to other behaviors related to performance and to the stress of performing. Cammarota et al[25] reported also that LPR symptoms could be induced in some singers by the increased abdominal pressure used during continuous vocal performance.

We have several hypotheses as to why LPR became more frequent in follow-up examinations in our subjects. With training, there may be an increased frequency of performances and likely an increased level of stress. We also believe that MTD decreased with improved technique; more efficient support using the abdominal, back, and thoracic muscles may

have occurred, thus increasing intraabdominal pressure. This could have contributed to the increase in the diagnosis of LPR. In addition, we hypothesized that those patients who were noncompliant with reflux treatment were more likely to seek follow-up evaluation for dysphonia. These combinations of factors may have contributed to a higher diagnosis of LPR.

Other studies have documented the frequencies of abnormalities in dysphonic patients. In a Brazilian tertiary voice clinic, 163 professional voice users (25% singers) who had voice complaints were found to have nodules (36%), minor structure change (24% including cyst, sulcus, mucosal bridge, and vascular dysgenesis), and LPR (12%).[26] In Belgian patients seeking voice treatment ($n = 882$), Van Houtte et al[27] reported in 2010 that the prevalence of pathology was 30% MTD, 15% VF nodules, and 9% LPR. From this population, 41% were professional voice users (mainly teachers with some singers and actors), and among them, the prevalence of pathologies included 41% MTD, 15% VF nodules and hypertrophy, and 11% LPR.[27] Coyle et al[28] reported that in a population seeking treatment for voice disorders ($n = 1158$), 18.4% of patients had LPR, 17.9% had masses (polyps and nodules), 12% had VF paralysis, and 8.5% had laryngitis. When our results were compared with these previous studies, our symptomatic patients had higher frequencies of LPR (90.3%), VF hypomobility (36.3% unilateral and 5.9% bilateral), and glottic insufficiency (40.6%).

In our study, we found that there was a slight decrease in MTD between the initial examinations (49.0%) and follow-up examinations (40.1%). Although this was not statistically significant, it could be explained by an improvement in technique through intensive singing training of the singers after the initial examination, and of voice therapy in some cases. For other pathologies such as sulcus, VF hypomobility, VF mass, vascular abnormality, amplitude asymmetry, phase asymmetry, and incomplete glottic closure, we also found that there was no difference in the prevalence between the initial and follow-up examinations. Some of these pathologies could cause dysphonia, but they have also been found in patients with no voice complaints. Although different laryngeal abnormalities have been found in our singers, trained singers who have had these abnormalities for many years may compensate for these "pathologies."

The retrospective nature of our study is a limitation. A complete data set was not available for all subjects, specifically RFS, which was included more recently in our examination protocol. When subjects presented to the office for subsequent SVL, documentation of the details of the presenting voice complaints was not always available for review. However, students were referred from their institution for follow-up examination only when a complaint of dysphonia was present. Finally, multiple laryngologists/laryngology fellows performed the SVLs over the years of this study, and no interrater reliability study could be performed. However, all examinations performed by a laryngology fellow were reviewed by a senior laryngologist, almost always during the patient visit and always on the same day.

Our study had several strengths. We had 188 total SVLs, and our sample size of $n = 51$ was similar to that in previous studies: Elias et al[3] ($n = 65$), Lundy et al[4] ($n = 65$), and Sataloff et al[5] ($n = 72$). Our patient population was a homogenous group of opera students who were all high-level performers. Our study incorporated a more inclusive list of pathologies and our diagnostic capabilities might have improved, possibly leading to more sensitive detection of the vocal pathology present in this patient population. In addition, our study differed from previous studies of singers in that we compared the initial screening SVL with subsequent SVL examinations when the students presented with voice complaints.

We would like to stress the importance of using the baseline SVL to establish what was "normal" in each individual singer and using this information to diagnose patients accurately when they present with dysphonia that easily could be attributed incorrectly to asymptomatic, preexisting pathology. In addition, we believe that although high-level performers with one or more laryngeal pathologies may be asymptomatic in the short term, prospective studies are needed to follow the natural history of these pathologies and determine their long-term importance. Finally, when singers present with dysphonia, the nature of their voice complaint does not necessarily correlate with stroboscopic findings.[29] Therefore, the abnormalities seen in SVLs of professional voice users do not always require intervention just because they report dysphonia. Treatment should be tailored, on the basis of the individual's history, background, and voice use.

CONCLUSIONS

The prevalence of abnormal laryngeal findings of elite opera students was not statistically different from initial screening SVL examinations (90.2%) compared with their subsequent examinations performed for acute vocal complaints (94.9%), and both values are higher than those reported previously. In these singers, the most common pathology was LPR and the prevalence of this pathology increased significantly between the initial and subsequent examinations. The higher frequencies of abnormal findings in this study might be due to a more inclusive list of abnormal pathologies, increased experience with the interpretation of SVL, and improvements in technology. The high prevalence of abnormal findings in asymptomatic opera singers highlights the importance of baseline examinations in professional voice users.

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