Primary Presentations of Laryngomalacia

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**IMPORTANCE** Laryngomalacia (LM) classically presents with stridor in early infancy but can present atypically with snoring and/or sleep-disordered breathing (S-SDB) or swallowing dysfunction (SwD). The epidemiology of these atypical presentations has not been established in the literature.

**OBJECTIVE** To document the primary modes of presentation for LM in a consecutive series of children and to compare the characteristics of each subgroup.

**DESIGN, SETTING, AND PARTICIPANTS** Retrospective case series in a single tertiary pediatric otolaryngology practice. Outpatient and surgical records were searched for patients diagnosed as having LM from 2002 to 2009. We included all children with endoscopically confirmed LM without prior documentation of the diagnosis (n = 88).

**INTERVENTIONS** Patients were investigated and managed according to the routine practice pattern of the senior author.

**MAIN OUTCOMES AND MEASURES** The primary outcome measure was the proportion of the various primary presentations of LM. Age, sex, type of LM, management, and secondary diagnoses were also collected. Subgroup analysis was performed.

**RESULTS** Of 117 potentially eligible patients identified, 88 children had a confirmed diagnosis of LM and were thus included (1.9:1 male to female sex ratio; mean [SD] age, 14.5 [23.0] months; age range, 0.2-96.0 months). Fifty-six children (64%) presented primarily with awake stridor and variable respiratory distress; 22 (25%) with S-SDB; and 10 (11%) with SwD. The difference in mean (SD) age for each group was statistically significant by analysis of variance: stridor, 3.5 (2.8) months; S-SDB, 46.0 (27.2) months; and SwD, 4.8 (4.6) months ($P < .001$). By $\chi^2$ analysis, sex distribution was not significantly different between subgroups ($P = .29$), nor was the proportion of children who underwent supraglottoplasty ($P = .07$). The difference in proportion of types of LM between the stridor and atypical presentations was statistically significant ($\chi^2 P < .05$), with type 1 LM predominating in children presenting with S-SDB.

**CONCLUSIONS AND RELEVANCE** Because LM may present primarily with S-SDB and SwD in a significant proportion of children, the diagnosis must be considered in patients presenting with these upper airway complaints. The morphologic type of LM may vary by presentation.
Laryngomalacia (LM) is classically described as presenting with stridor in early infancy.\(^1\) By convention, most cases are self-limiting and are managed conservatively. In that context, supraglottoplasty has been reserved for children with more severe respiratory distress.\(^2,3\)

Within the last decade, various atypical primary presentations (other than stridor) of LM have been reported. These include symptoms of snoring or sleep-related breathing disorder (S-SDB), swallowing dysfunction (SwD), and/or unusually late onset of clinical problems.\(^4-9\) Researchers have also proposed that LM may be state dependent, manifesting only during sleep or precipitated by exercise.\(^7,10-13\)

Concomitantly, some series have gone on to report the success of supraglottoplasty in alleviating symptoms in these atypical situations.\(^4,5,8,9\)

We have noticed that large series reporting presenting features have focused on classic LM and excluded older children and atypical presentations.\(^14,15\) Therefore, to our knowledge, there are no large studies that document the distribution of these presentations and the characteristics of these subgroups within a large population of children diagnosed as having LM. Our aim herein is to report the primary presentation of a consecutive series of children who were diagnosed as having LM and to compare the parameters associated with these presentations.

**Methods**

This is a retrospective medical chart review of a consecutive series of children diagnosed as having LM in a single pediatric otolaryngology practice; as such, no informed patient or guardian consent was required of participants. All children were treated at the same tertiary pediatric referral center by 1 surgeon (H.E.-H.). Approval was obtained from the Research Ethics Office at the University of Alberta, Edmonton.

All patients diagnosed as having LM between 2002 and 2009 were identified by searching diagnostic codes of outpatient clinic records, an electronic repository of clinic letters, and a prospectively kept surgical database. Clinic letters were populated according to a uniform format (demographics, primary presenting features/diagnosis, comorbid diagnoses whether otolaryngologic or not, procedures performed during the clinic visit, and planned treatment method[s] or investigations). The surgical database contains demographics, otolaryngologic and nonotolaryngologic diagnoses (up to 4), method of anesthesia, urgency, procedures performed (up to 6), special instrumentation (and setting), and complications.

All children (≤17 years) with an endoscopically confirmed new diagnosis of LM without prior documentation of the diagnosis were eligible for inclusion in the study. The diagnosis of LM and assignment of type was in accordance with the classification system first described by Olney et al.\(^16\) This classification is based on the site of supraglottic obstruction in LM. Type 1 involves prolapse of the arytenoid cartilage mucosa; type 2 has shortened aryepiglottic folds; and type 3 is caused by posterior epiglottic displacement. Patients were excluded if airway endoscopy was not performed to confirm the LM diagnosis, key data were absent from the medical records, medical records were missing, or LM was erroneously diagnosed. Patients were also excluded if they had previously received treatment for LM elsewhere.

Variables collected included the patient’s age at time of diagnosis, sex, primary presenting complaint (stridor, S-SDB, SwD), presence or absence of symptoms, endoscopically evaluated type of LM (1-3), comorbidities, surgical procedures performed, and investigations related to the presenting features. Data was collected from both hospital and clinic charts.

**Definitions of Study Terms**

*Primary presentation* was defined as the most concerning symptom for the parent and the referring physician per the letter of referral. *Stridor* was defined as noisy breathing while awake with all of the following characteristics: (1) not primarily related to feeding; (2) possibly but not necessarily associated with varying degrees of increased work of breathing manifested by suprasternal and costal retractions; (3) tachypnea; and (4) absence or presence of cyanotic spells and/or apparent life-threatening episodes. *Swallowing dysfunction* included choking, congestion or coughing, difficulty feeding, or recurrent lower respiratory tract infections and was evaluated with either a clinical swallowing assessment or a video-fluoroscopic swallowing study (VFSS). Swallowing studies were rated to show normal swallow, penetration, or aspiration.

Snoring and/or sleep-disordered breathing was defined as snoring, disrupted sleep related to breathing difficulty, and other nocturnal or diurnal symptoms. Children with S-SDB were further assessed with either polysomnography (PSG) (abbreviated or full) or an overnight pulse oximetry (PO) study. The McGill oximetry score is a validated 4-level severity score of desaturation events from overnight pulse oximetry testing. A score of 2 is consistent with moderate obstructive sleep apnea (OSA) and requires 3 or more oxygen desaturations under 90% but greater than 85%. A score of 3 requires 3 or more desaturations under 85% but greater than 80%. A score of 4 requires more than 3 desaturations under 80% and is consistent with severe OSA. The presence or absence of any of these presentations was rated as (1) or (0) respectively. Sleep study results were considered abnormal if the PO result was 2 or higher, with scoring as described by Nixon et al.,\(^17\) or the apnea-hypopnea index was greater than 1 per hour.\(^18\)

Associated comorbidities were defined and documented as follows: *gastroesophageal reflux disease* (GERD) was diagnosed based on a combination of history of classic symptoms, history of or response to treatment with proton pump inhibitors, esophagoscopy/gastroscopy with biopsy, or pH probe study results. *Prematurity at birth* was defined as gestational age of 36 weeks or less. *Obese children* were those with a documented BMI in the 97th percentile or higher. Presence of neurologic conditions and metabolic and congenital cardiac defects were all determined by the diagnoses of the respective specialists.

Airway endoscopy was performed with a 2.2-mm flexible endoscope, while the patient was either awake or sedated with intravenous propofol and remifentanil, allowing for spontaneous ventilation. Some of the patients additionally had la-
primary presentations of LM. Secondly, we compared the subgroups of primary presentation with regard to age, sex, type of LM, rate of supraglottoplasty, and comorbidities.

**Statistical Analysis**

Descriptive statistics including means, standard deviations, and frequencies were calculated. Means were compared using Analysis of Variance (ANOVA) Calculator–One-Way ANOVA from Summary Data, 2012 (http://www.danielsoper.com/statcalc3). Comparison of proportions was performed using variants of the χ² test in Microsoft Excel using templates from www.radford.edu/biol-web/stats/chi-sq2X3template.xls and www.stat.wmich.edu/s216/ExcelTools/3x2ChiSq.xls. Statistical significance was accepted as \( P < .05 \) in all cases. Individual patient data forms were used for initial collection of variables, and then data were transferred to a Microsoft Excel spreadsheet.

**Results**

From a search of clinic records and the surgical database, 117 children were identified as having the diagnosis of LM. Of the 117, 88 were included, and 29 were excluded. Of those excluded, 18 had insufficient data available in their clinical records or had an incomplete description of the endoscopic appearance of LM. Five children did not have airway endoscopy performed owing to inability to obtain parental consent or situation-specific time and equipment constraints. Six were found to have an erroneous diagnosis of LM on further review of their records.

Of the 88 children included, 58 were boys, and 30 were girls (male to female ratio, 1.9:1). The mean (SD) age of the children was 14.5 (23.0) months (range, 0.2-96.0 months). The follow-up period varied: some patients with mild LM had only a single follow-up visit compared with those requiring complex management of either LM or other otolaryngologic diagnoses necessitating long-term follow-up. The standard minimum duration of follow-up within the practice is a 3-month follow-up visit for patients managed conservatively to ensure symptom resolution or 3-month postoperative visit for those undergoing supraglottoplasty.

All children were assessed initially with flexible endoscopy while awake. Additionally, 73 had an endoscopy performed while sedated and spontaneously breathing, which was performed either as part of a complete airway endoscopy or as an adjunct to another scheduled procedure. The primary presenting complaint was stridor in 56 children, S-SDB in 22, and SwD in 10 (Figure 1). Stridor was also the most common symptom reported on presentation. Sixty-seven children had stridor or a history of stridor when they presented. Sixty children had complaints related to SwD, and 43 had sleep-related complaints (Figure 2). Fifty-nine children reported 2 or more categories of symptoms, of which 24 had complaints pertaining to all 3 presentations. Twenty-eight children presented with stridor and SwD, 4 with S-SDB and SwD, and 3 with stridor and S-SDB. There were 37 overnight PO and 14 PSG studies performed in total as part of the initial assessment of the children. Twenty-five children had abnormal findings of sleep studies. Ten had a...
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Table. Comparison of Subgroup Characteristics

<table>
<thead>
<tr>
<th>Presentation</th>
<th>Age, Mean (SD), mo</th>
<th>P Value(^a)</th>
<th>M:F Ratio</th>
<th>P Value(^b)</th>
<th>Supraglottoplasty, No. (%)</th>
<th>P Value(^b)</th>
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<tbody>
<tr>
<td>Stridor</td>
<td>3.5 (2.8)</td>
<td>.29</td>
<td>1.8:1</td>
<td></td>
<td>31 (55)</td>
<td>.07</td>
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<td>(n = 56)</td>
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<td>S-SDB</td>
<td>46.0 (27.2)</td>
<td>&lt; .001</td>
<td>3.4:1</td>
<td>.29</td>
<td>6 (27)</td>
<td>.07</td>
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<tr>
<td>(n = 22)</td>
<td></td>
<td></td>
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<tr>
<td>SwD</td>
<td>4.8 (4.6)</td>
<td></td>
<td>1:1</td>
<td></td>
<td>4 (40)</td>
<td></td>
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<td>(n = 10)</td>
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Abbreviations: SwD, swallowing dysfunction; S-SDB, snoring and/or sleep-disordered breathing.

\(^a\) P value calculated using analysis of variance.

\(^b\) P value calculated using \(\chi^2\).

Figure 3. Distribution of Types of Laryngomalacia by Primary Presentation

Types of laryngomalacia assigned according to the classification system of Olney et al.\(^{16}\) S-SDB indicates snoring and/or sleep-disordered breathing; St, stridor; SwD, swallowing dysfunction.

Twelve children underwent both tonsillectomy and adenoidectomy; 5 children had adenoidectomies; 1 had a tonsillectomy; and 1 had a lingual tonsillectomy. Of these 12 children, 8 had supraglottoplasties as well. The majority of these 19 children presented primarily with S-SDB, although 3 had initially presented with stridor and 1 with SwD.

The types of LM found in each subgroup of primary presentation are shown in Figure 3. Of the children presenting primarily with stridor, 27 had type 1, 28 had type 2, and 1 had type 3. In the S-SDB group, 15 children had type 1, 4 had type 2, and 3 had type 3. For the 10 children presenting with SwD, 5 had type 1, 4 had type 2, and 1 had type 3. The difference in proportion of types of LM was statistically significant between stridor and atypical presentations (S-SDB or SwD) \(\left(\chi^2 P < .05\right)\). Types 1 and 3 appeared relatively more frequently in the S-SDB group.

Some of the patients in the series were previously reported by Thesavagay et al\(^a\)\(^9\) in a series looking at the prevalence of LM in children presenting with SDB. Also, the 88 children included in this series overlap with the cross-sectional observational study by Rifai et al\(^a\)\(^20\) on secondary airway lesions in LM.

Discussion

The demographics of our study population are comparable to those of other series depicting variations of presentation of LM. Our study, with a 1.9:1 male to female ratio, is consistent with the male predominance reported in other LM series.\(^{9,14,15}\) The mean (SD) age of 14.5 (23.0) months is older than the age in those series describing classic laryngomalacia presentations.\(^{14,15}\)

Currently published large series of LM describe classic or congenital LM.\(^{14,15}\) These series report that 100% of patients presented with stridor. In contrast to the current work, these studies exclude those patients presenting atypically or at an older age. Our results portray a very different picture of LM as a whole. While stridor was the most common primary presentation, 36% of children presented with SwD or S-SDB, and 24% of children did not have concomitant stridor or any history of it. We believe that this is more representative of LM taken as a whole in an otolaryngology practice.

Our study also demonstrates some important differences between the subgroups of primary presentations. Children presenting with S-SDB were significantly older at the time of di-

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Original Investigation

JAMA Otolaryngology–Head & Neck Surgery
June 2014 Volume 140, Number 6

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The mean (SD) age of this subgroup in our series, 46.0 (27.2) months, is comparable to those reported in other series describing similar populations.4,5,8,9 Male sex dominated among the subgroups of stridor (nearly twice as many boys as girls) and S-SDB (more than 3 times as many boys as girls), but the sexes were equally represented in the SwD group. Probably owing to the small numbers in the SwD group, these differences did not reach statistical significance.

Olney et al16 first described this classification scheme for LM based on the site of supraglottic collapse (judged endoscopically) in 47 children, and it was intended to guide appropriate surgical management. Type 1 LM was the most commonly encountered (57%). There were no statistically significant differences in the age of resolution of LM symptoms or the rate of surgical intervention based on type. Presenting features were not stratified in this study by swallowing or sleep-related issues. The authors concluded that type of LM was useful in classification but did not have significant prognostic or treatment implications, and this has generally been accepted since publication of the study by Olney et al.16

After analyzing the distribution of types of LM, we found statistically significant differences between those patients presenting with stridor and those with atypical presentations (S-SDB and SwD). Types 1 and 3 LM were more common in children with S-SDB primary presentations. While the predominance of type 1 LM in older children with sleep-related symptoms has been reported previously by Revell and Clark,4 the study was a comparison of select groups rather than an epidemiologic study of prevalence. Richter et al8 also described a predominance of type 1 LM in children with both feeding and sleep-disordered LM, although the distributions were not quantified. Thevasagayam et al9 reported a more even distribution of LM types in children with concomitant S-SDB: 6 children with type 1, 5 with type 2, and 3 with type 3 LM.

At a minimum, all children included in the present study underwent airway endoscopy while awake in the outpatient clinic; many had a complete examination performed during spontaneous ventilation under general anesthesia when indicated. It is not believed that a subset of patients with less severe LM symptoms was excluded based on this inclusion criterion: airway endoscopy was routinely performed on all patients for whom the diagnosis of LM was considered in this pediatric otolaryngology practice. A very small number of children (n = 5) did not have an endoscopy performed owing to parental refusal or, rarely, time and equipment constraints. We believe that the documentation in the current study is more robust than if the diagnosis was assumed without endoscopy in classically presenting infants with mild symptoms, as occurs in some practices.

The numbers of children undergoing supraglottoplasty in each subgroup varied subtly and did not reach statistical significance. However, the overall rate was 47%, which exceeds the relatively wide range reported in the literature (4%-28%).16-18,21 Surgical intervention in our practice is not based solely on the presence of stridor with increased work of breathing, cyanotic spells, apparent life-threatening episodes, and failure to thrive. We also solicit symptoms of S-SDB and SwD, which explains the increased rate of intervention.

Although response to surgical intervention is beyond the scope of this article, other authors have described relative success with supraglottoplasty in children presenting with atypical presentations for LM. Richter et al8 reported resolution of symptoms following supraglottoplasty in 17 children older than 2 years who presented with feeding-disordered, sleep-disordered, or exercise-induced LM. Thevasagayam et al9 describe symptom resolution in 3 of the 6 patients undergoing supraglottoplasty who had both LM and S-SDB. In the series reported by Revell and Clark,4 treatment response was broken down by severity of LM and adenotonsillar hypertrophy. Patients had varying responses to supraglottoplasty and/or adenotonsillectomy, depending on the severity of their LM or adenotonsillar obstruction and the appropriate surgical management based on the anatomic cause of their predominant symptoms. In a surgical series of children older than 1 year with both SDB and LM by Digoy et al,5 there was a statistically significant improvement in apnea-hypopnea index and minimum oxygen saturation on PSG following supraglottoplasty as well as subjective symptom improvement in the majority of children.

It is not uncommon to find significant adenotonsillar enlargement and also other nasal and tongue base disease along with LM during sleep nasopharyngoscopy. The simpler surgery is performed for tongue base disease, along with the choice that does not alter the general plan for admission and nursing. At follow-up, a reassessment of symptoms and, when necessary, a repeated sleep study is undertaken to determine the requirement of further procedures.

Once a child has been diagnosed as having SDB based on a persistent symptom complex and findings of a sleep study (minimally an overnight PO), a consideration of the role of medical treatment is made. If surgery is deemed to be the next step, sleep nasopharyngoscopy during spontaneous ventilation is routinely planned, along with possible adenotonsillectomy (given other indications for this surgery and the clinical examination findings). It is the senior author's experience (H.E.-H.) that office endoscopy allows planning for other nasal interventions to be considered but cannot modify or predict pharyngeal or laryngeal findings.

Concurring with prior literature, we found that GERD was very common in our series: 42 children (48%) received this diagnosis. The prevalence of GERD in LM has been reported to range from 65% to 100%.22 Our lower prevalence of GERD within our study population compared with other studies of LM may be attributed our use of a conservative threshold for diagnosis. The diagnosis was based on a combination of a history of classic symptoms, history of or response to treatment with proton pump inhibitors, and results of evaluations including esophagogastroscopy and pH probe. Evidence of laryngopharyngeal reflux on endoscopy was not used to diagnose GERD but is used by other authors, even as a sole criterion, for the diagnosis of GERD.23

Neurologic conditions with reduced tone are also known comorbidities in LM and have been used in support of a neu-
anogenic theory of LM.22 While 9 children in this series had a neurologic condition diagnosed, these were not cases where generalized hypotonia confounded the diagnosis of LM.

There was a high rate of aspiration and penetration within the study population: 29 patients had abnormal VFSS or clinical swallowing assessments. This, in combination with the primary presentation of SwD and secondary complaint of SwD features in many patients going on to be diagnosed as having LM, adds weight to the argument for swallowing assessments in all patients diagnosed as having LM.

A limitation of our study is its retrospective design. Despite the surgeon (H.E.-H.) adopting a standard protocol for managing LM and requesting investigations such as sleep and swallowing studies, this became a consistent exercise in the latter five years of the study, and recourse to PSG was restricted by local availability. We also were subject to parental (and patient) compliance and preference, and there was no intention to exclude patients based on deviation from that. Furthermore, our data cannot be used to support a causal relation between LM, its types, or the atypical clinical manifestations documented. However, the findings are in line with various other reports on atypical presentations, despite not including the exercise-induced variants, and it represents one of the larger consecutive series to date.

Given the variations between the primary presentations of LM, further research into any potential differences in treatment outcomes would certainly be of value. Again, surgical series on various presentations of LM have been reported. However, to our knowledge, a comparison of supraglottoplasty outcomes with regard to type of LM and presenting features in a large series of patients does not exist to date. Prospective longitudinal cohort studies with sequential endoscopy and planned investigative protocols are needed.

Conclusions

In conclusion, LM may present with a variety of manifestations, and those traditionally considered atypical are not that uncommon. Airway endoscopy is the only definitive way to confirm or rule out the diagnosis of LM in children presenting with a complaint related to the upper airway. Further research is required to clarify if LM as described is a single entity or may in fact be a manifestation of several distinct disease processes.

ARTICLE INFORMATION

Submitted for Publication: November 14, 2013; final revision received February 15, 2014; accepted March 19, 2014.


Author Contributions: Dr Cooper had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Cooper, Benoit.

Acquisition, analysis, or interpretation of data: Cooper, Benoit, Erickson, El-Hakim.

Drafting of the manuscript: Cooper, Benoit, El-Hakim.

Critical revision of the manuscript for important intellectual content: Erickson.

Statistical analysis: Cooper, Benoit, El-Hakim.

Administrative, technical, or material support: Cooper, Benoit, Benoit.

Conflict of Interest Disclosures: None reported.

Previous Presentation: This research was presented at the annual meeting of the Society of Ear, Nose, and Throat Advances in Children; November 30, 2012; Charleston, South Carolina.

REFERENCES