Synchronous airway lesions in laryngomalacia

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Objective: Laryngomalacia is the most common cause of congenital stridor. Laryngomalacia may be associated with other structural and functional airway lesions. While previous studies suggested a 10–45% rate of synchronous airway lesions (SALs), the exact rate and its clinical significance is unknown. The purpose of this study was to determine the prevalence of SALs below the glottic level in congenital laryngomalacia, and to investigate possible relations with other clinical findings.

Methods: A cohort of 228 infants with congenital stridor who underwent fiberoptic flexible bronchoscopy (FFB) was analyzed. Data was collected from the hospital records. All procedures were reevaluated from the video recordings.

Results: SALs below the vocal cords were observed in 7.5% of the case (17/228). The most common SAL was tracheal bronchus followed by tracheomalacia and stenosis of the left main bronchus. No correlation was found between the presence of a SAL below the vocal cords and any other medical condition except for neurodevelopmental disorders. Except for one patient, all cases with SAL did not have any clinical symptoms or signs that would have suggested an accompanying airway lesion.

Conclusions: The rate of SALs in infants with congenital stridor due to laryngomalacia is low and most of the additional lesions are benign. The yield of discovering clinically significant SALs below the glottic level is low and the routine search for a synchronous
1. Introduction

Laryngomalacia constitutes the major cause of congenital stridor [1]. In most cases, this disorder is a benign and self-limited condition that resolves without intervention by 2 years of age [2]. Several studies have shown that laryngomalacia may be associated with other structural and functional airway lesions [1,3–8]. The frequency of such associated airway anomalies has been reported to range from 10 to 45% of laryngomalacia cases [1,4,5,7–11]. Since these synchronous airway lesions (SALs) are below the glottic opening, they usually cannot be observed during laryngoscopy alone, either directly or by the flexible fiberoptic technique. In addition, secondary lesions at the level of the vocal cords, such as unilateral or bilateral vocal cord paralysis or posterior laryngeal cleft, may be missed on awake transnasal flexible laryngoscopy in the presence of laryngomalacia. It has, therefore, been recommended that the endoscopic evaluation of laryngomalacia should be completed by including evaluation of the lower airways [4–6,9,12]. This may be achieved during the same session when anesthesia and deep sedation are already being used for the laryngoscopy or as a separate procedure following evaluation of laryngomalacia using local anesthesia in the outpatient clinic. In any case, bronchoscopy of the lower airways requires general anesthesia or deep sedation, is time consuming, costly and although ambulatory, requires admission to the hospital. Since laryngomalacia is usually a benign lesion, others recommend performing only flexible fiberoptic laryngoscopy in the doctor’s office or clinical follow-up without tracheobronchial endoscopy in at least mild and typical cases. The decision to scope also the lower airways in cases of laryngomalacia depends mainly on the expected benefit of this procedure, i.e. the probability that an accompanying lesion is found, its nature and clinical significance.

The evidence that previously suggested that visualization of the tracheobronchial tree should be added is sparse and comes mainly from studies that used rigid bronchoscopies. Also there are methodologic variations and inconsistencies. The clinical significance of these synchronous airway lesions was not assessed. The purpose of this study was to determine the prevalence and type of synchronous airway lesions in congenital laryngomalacia patients, and to investigate possible relations between lesions below the glottis and other clinical findings using a blinded study protocol that separated the scoring of a SAL from the clinical presentation and treatment of the airway problem.

2. Patients and methods

The study comprised all infants who were evaluated for congenital inspiratory stridor and were diagnosed with laryngomalacia using fiberoptic flexible bronchoscopy (FFB) between January 1994 and December 2004 in two institutions. During the study period, the two hospitals, the Tel Aviv Medical Center and the Hadassah Ein-Kerem Hospital, Jerusalem (hospitals 1 and 2 respectively, both in Israel), utilized FFB under general anesthesia/deep sedation in all cases of congenital stridor and routinely scoped the airways below the vocal cords in all cases. These two hospitals serve as tertiary referral centers. In all cases the FFB was recorded on a videotape that was available for review. The study was approved by the institutional review boards of both hospitals.

2.1. Procedure and monitoring

All FFBs were done transnasally with the patient breathing spontaneously. Sedation for the procedure included: (1) IV Propofol (loading dose 2.5 mg/kg with subsequent boluses as needed); (2) Ketamine (1–2 mg/kg) following midazolam (0.1–0.2 mg/kg loading dose); or (3) inhaled Sevoflurane. During the procedure, all infants received 100% oxygen by an anesthesia mask or a continuous flow of 2–3 l/min of 100% oxygen administered directly to the hypopharynx by a 8 Fr. feeding tube. The bronchoscopies were performed by a senior pediatric pulmonologist with the assistance of a pediatric intensivist or an anesthesiologist and a registered nurse. Oxygen saturation, respirations, blood pressure and electrocardiogram were continuously monitored during all procedures.

The endoscopies were performed using a Pentax™FB-10V or FB-8V bronchoscope (Pentax, Tokyo, Japan) with a distal outside diameter of 3.5 or 2.8 mm respectively. Initially, only the upper airways were investigated looking for the cause of the stridor. Following completion of upper airway evaluation and assessment of vocal cords motion, Lidocaine 1% was applied to the glottis and the
bronchoscope was advanced to visualize the trachea and main bronchi. All endoscopies were recorded on videotape.

2.2. Data collection and analysis

The information retrieved for all infants with a diagnosis of laryngomalacia included data from: (1) the hospital records, (2) the bronchoscopy report, and (3) reevaluation of the bronchoscopy video recordings. The data obtained from the charts included: gender, age at diagnosis, gestational age, clinical findings in addition to stridor, clinical sequel of laryngomalacia such as gastro-esophageal reflux disease (GERD), pectus excavatum and failure to thrive (FTT) and any other unrelated medical problems. All bronchoscopy reports were evaluated and all comments and findings were noted. The review of the video recordings included: (a) confirmation of the diagnosis of laryngomalacia, (b) search for synchronous airway lesions, and (c) scoring of the degree of laryngomalacia using the laryngomalacia video score (Table 1) [13]. The reviewer was blind to the original interpretation of the airway anatomy. The cases managed in the hospital 1 were reviewed by a pediatric pulmonologist that joined the team after 2004 (JBA) and the cases of hospital 2 were reviewed by a pediatric pulmonologist from hospital 1 (YS). This was performed to insure that the study was not analyzed by the original bronchoscopist. Only when the original diagnosis matched the reassessment, the diagnosis was accepted for analysis. In cases where an obstructive or endotracheal lesion was observed, the degree of the airway narrowing was estimated by the percentage of airway cross sectional area that was obstructed. In cases of intermittent or dynamic narrowing, the maximal narrowing was assessed. Tracheomalacia was defined as a dynamic collapse of at least 50% of the airway lumen on expiration during spontaneous breathing [14–17].

The data was analyzed for the rate of synchronous airway lesions, number of synchronous airway lesions per infant, relation of the existence of an accompanying airway lesion to the degree of laryngomalacia by the laryngomalacia score and the relation of the synchronous airway lesions to demographic and clinical variables.

2.3. Statistical analysis

Fisher’s exact test and the Mann–Whitney non-parametric test were used for comparisons. Analysis was performed using the SPSS for Windows version 12.0 software. Statistical significance was set at $p < 0.05$.

3. Results

Two hundred and twenty-eight cases were included in the study. 144 were male (63%). In two cases the diagnosis of laryngomalacia was not clear from the video recordings. These cases were not excluded because both cases had been referred for congenital persistent stridor, no other cause for the stridor was found, the clinical picture on presentation and during follow-up was characteristic for laryngomalacia (“cog-wheel” type stridor that improved in prone position and during relaxed breathing), both resolved before the infants were 14 months old without any treatment, and the original report of the laryngobronchoscopy specified the finding of laryngomalacia. The mean age at the clinical presentation (stridor) was 8 weeks (median = 6, range = birth to 10 weeks). In 209 infants (92%) the stridor started before 2 weeks of age. The mean age at diagnosis (FFB) was 16 weeks (median = 13,

<table>
<thead>
<tr>
<th>Finding</th>
<th>Score</th>
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<tbody>
<tr>
<td><strong>(A) Arytenoid score</strong></td>
<td></td>
</tr>
<tr>
<td>No discernible collapse into glottis with inspiration</td>
<td>0</td>
</tr>
<tr>
<td>Subtle collapse of arytenoids into glottis</td>
<td>1</td>
</tr>
<tr>
<td>Collapse of arytenoids into glottis, 25-50% of vocal cords obscured</td>
<td>2</td>
</tr>
<tr>
<td>Collapse of arytenoids into glottis, about 75% of vocal cords obscured</td>
<td>3</td>
</tr>
<tr>
<td>Collapse of arytenoids into glottis, 100% of vocal cords obscured</td>
<td>4</td>
</tr>
<tr>
<td><strong>(B) Epiglottic score</strong></td>
<td></td>
</tr>
<tr>
<td>Normal epiglottis, no folding during inspiration</td>
<td>0</td>
</tr>
<tr>
<td>Slight length-wise folding of epiglottis</td>
<td>1</td>
</tr>
<tr>
<td>Moderate fold of epiglottis without contact between lateral edges</td>
<td>2</td>
</tr>
<tr>
<td>Intermittent contact of lateral edges of epiglottis</td>
<td>3</td>
</tr>
<tr>
<td>Continuous contact and even overlap of lateral edges of epiglottis</td>
<td>4</td>
</tr>
</tbody>
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Table 2  Synchronous airways lesions found in infants with congenital stridor due to laryngomalacia

<table>
<thead>
<tr>
<th>Synchronous airway lesion</th>
<th>Number of cases</th>
</tr>
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<tbody>
<tr>
<td>Tracheal bronchus\a</td>
<td>8</td>
</tr>
<tr>
<td>Stenosis of the left main bronchus</td>
<td>4</td>
</tr>
<tr>
<td>Stenosis of the right upper lobe bronchus</td>
<td>1</td>
</tr>
<tr>
<td>Tracheomalacia\b</td>
<td>5</td>
</tr>
</tbody>
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\a In all cases the bronchus to the right upper lobe originated from the trachea proximally to the bifurcation, in 4/8 the bronchus originated at the level of the carina.

\b One case had both tracheal bronchus and tracheomalacia.

range 1–28 weeks). No significant side effects or complications occurred during or immediately after the diagnostic bronchoscopies. Minor side effects and complications were observed in 11 infants (4.8%) including laryngospasm, temporary hypoxia, agitation, and supraventricular tachycardia (one case) that completely resolved within a short time.

Synchronous airways lesions were observed in 7.5% of the case (17/228). No difference was found between the two hospitals (5/85 = 5.9% and 12/143 = 8.4%, hospitals 1 and 2 respectively, \( p = 0.6 \)); hence the data was combined. The accompanying lesions are presented in Table 2. All were below the glottic level. Normal vocal cord motion was observed in all cases. Only one case had more than one accompanying lesion. In all 8 cases of tracheal bronchus the right upper lobe bronchus was involved without tracheal narrowing. In 4/8, the bronchus originated at the level of the carina or immediately proximal to the carina.

Twenty-one infants (9%) were diagnosed as having GERD, 5 (2%) had pectus excavatum, 15 (7%) suffered from FTT and 10 (4%) infants had other unrelated medical problems. No correlation was found between the presence of a SAL below the vocal cords and any of these findings. Also, no relation was found to patient’s gender. There was no correlation between the occurrence of a SAL and the degree of the laryngomalacia by the video score and no relation was found between the presence of a SAL and side effects or complications during the bronchoscopy.

Thirteen infants were born preterm (<37 gestational weeks). Seven of them received assisted ventilatory support through an endotracheal tube (ETT). No term-born infants were intubated prior to diagnosis. SALs were more common in the preterm-born infants (2/13 = 15% vs. 11/211 = 5%) and in those who received assisted ventilation (2/7 = 29% vs. 5/211 = 2%). However, these differences did not reach a statistical significance. Four infants out of the 17 (23%) who had a SAL had an underlying neuromodulatory problem that included muscle hypotonia (2 had Down’s syndrome and one CHARGE syndrome) compared with 9 infants with neurodevelopmental problems in the 211 infants who did not have a SAL (4.3%) (\( p = 0.01 \), Fisher’s exact test). The neurodevelopmental problems in those who did not have a SAL were Down’s syndrome, 1 case, Larsen syndrome, 1 case, and others, 7 cases (2 of whom had also hypotonia). The admission rate because of stridor or worsening of upper airways obstruction was not different between infants who had an additional airway lesion compared to those who did not. The overall admission rate of infants with SALs was, nevertheless higher, but this was due to admissions for evaluation and treatment of the other medical problems that these infants had. In two cases, both with SAL, the noisy breathing at presentation included expiratory noise and wheezing. One had bronchial narrowing and the other was the only patient who had severe tracheomalacia presented with life threatening episodes. This patient had an undiagnosed underlying neurologic disease with hypotonia and severe developmental delay on follow-up. All other 15/17 (88%) cases with SAL did not have any clinical symptoms or signs or any radiologic findings that were suggestive of an accompanying airway lesion and symptoms were limited to congenital stridor. Supraglottoplasty was performed in nine patients, only one had a SAL.

4. Discussion

The clinical implication of this study is that the rate of synchronous airway lesions that accompany laryngomalacia is low and that most of the associated lesions have minor significance. Other studies were inconclusive regarding the clinical implications that the rate and nature of the accompanying lesions may have on infants with laryngomalacia and on the decision to perform endoscopy of their lower airways. While laryngomalacia, in itself, is a benign, self-limited condition, the reported increased incidence of synchronous airway lesions up to 45% [5,6,8,9,12,18] has led some ENT physicians and pulmonologists to recommend complete evaluation of the tracheobronchial tree in order to diagnose lesions that require treatment and possible life threatening conditions [4—6,9,12]. However, other researchers [1,7,10,19] have concluded that the low incidence of clinically significant SALs does not justify the routine evaluation of the lower airways and that bronchoscopy should be reserved for selected patients with laryngomalacia who have severe or specific clinical symptoms. The recom-
Synchronous airway lesions in laryngomalacia

Recommendations whether to perform routine complete bronchoscopy in the different reports do not correlate with the rates of SALs in these studies. It should be noted that the studies that recommend routine inspection of the lower airways are relatively older, the latest was published 17 years ago. Our results that show a relatively lower incidence are in accordance with the more recent studies that suggest that bronchoscopy should be selective rather than routine.

Some of these, however, reported that more than 3% of the cases required surgical intervention [1]. The American College of Chest Physicians guidelines state that noisy breathing is a common indication for FFB in children, but do not recommend when to perform nasopharyngoscopy and when to limit the evaluation to laryngoscopy without FFB [20]. A similar statement has been published by the American Thoracic Society [21]. The European Respiratory Society has concluded that there was insufficient information on the frequency of SALs and recommended performing FFB in addition to nasopharyngoscopy and laryngoscopy in severe cases and hypoxemia [22].

Our study found a 7.5% incidence of SALs associated with laryngomalacia. This rate is lower than the rate found in previous studies [5,7—10]. There are several reasons for this discrepancy. Most previous studies used rigid laryngobronchoscopy alone [1,7] or rigid tracheoscopy combined with flexible laryngoscopy [23,10]. Rigid laryngobronchoscopy is superior in the detailed evaluation of airways anatomy, for example in studying the posterior glottic area and for lesions such as mild subglottic stenosis. However, it is not the preferred tool for evaluating airway dynamics due to the interference of the endoscope with the dynamic anatomical motion and with distortion of the airways structures during breathing that are mandatory for the diagnosis of laryngomalacia and other dynamic anomalies. Some of the previous reports combined both supraglottic, glottic and infraglottic lesions in their assessment of SAL frequency [1,6—8,10]. This, however, does not contribute to the decision whether to evaluate the infraglottic airways in laryngomalacia patients since supraglottic and glottic lesions are evaluated as a part of the endoscopy for congenital stridor. All previous studies were retrospective and were based on records review of procedures that had been performed and interpreted by different clinicians, both pulmonologists and ENT doctors. In the present study all procedures were reevaluated by critical and specific assessment of the video recordings. Only when the original diagnosis matched the reassessment, was the diagnosis considered. In previous reports, the decision to perform either laryngoscopy or complete laryngoscopy and bronchoscopy was not standardized. The strength of the present study is that all cases with congenital stridor were included and all had FFB. This was our clinical routine for all cases with congenital stridor during the study period, hence, unlike other studies a selection bias was not present and the results represent the entire cohort of laryngomalacia cases. Also, previous series included a small patients’ population therefore introducing a selection bias that affects the reliability of frequency determination [1,8,10,23].

This study is based on FFBs only, without rigid laryngobronchoscopies. Our data analysis reflects just those lesions found below the glottic level since only these lesions are relevant in the decision-making of whether to additionally scope the lower airways. We excluded all mild dynamic tracheomalacia cases since these where not associated with a significant anatomic obstruction of the airways and were not associated with any clinical symptoms and signs including tracheal noisy breathing (fixed noise with an expiratory component). Mild dynamic proximity of the tracheal walls without distortion of the tracheal rings may be observed during increased breathing efforts or cough in normal infants [14,16,17]. A study that looked at the frequency of pharyngeal wall collapse in infants with upper airway obstruction showed that laryngomalacia was present in 78% of the cases and that tracheomalacia, tracheal bulging, bronchial stenosis and bronchomalacia were the most common SALs below the glottic level [24].

For the general healthy infant population with laryngomalacia, risk factors for the existence of a SAL could not be identified. A trend towards a higher rate of SALs in preterm-born infants was observed, but this was not statistically significant. The numbers were, however, too small for meaningful interpretation. The only variable that was associated with increased rate of SAL was an underlying neurodevelopmental disease that was associated with hypotonia. Such an association has been observed in other studies [1,10,23—25]. A possible explanation is that in children at this age who suffer from hypotonia, the intercostal muscles are affected earlier and to a greater extent than the diaphragm. This may result in constant and significant chest retractions that may compress tracheal cartilage contributing to the development of tracheomalacia.

The lesions that were found in this study were, in all cases but one with a severe neurodevelopmental disease, benign incidental findings that did not affect outcome, were not associated with clinical conditions.


symptoms and did not require intervention. Tracheal bronchus accounted for about 50% of the findings with 50% of them being borderline. The main limitation of this study is its retrospective nature. This difficulty is present in all previous reports since they were based on retrospective chart reviews. We were able to overcome this limitation for defining the rate of SALs by reviewing each of the bronchoscopies video recordings and not relying only on bronchoscopies reports. Although this solved the limitation of SALs rate, it remained a limitation for identifying risk factors for SALs since correlation of SALs with outcome (growth, stridor disappearance, development) depended on notes in the charts. A prospective study is required to better delineate risk factors if these exist.

The criteria for defining severe laryngomalacia vary among different clinicians [4,23,25]. In this study, disease severity was represented by the laryngomalacia video score and the presence of associated complications (GERD, FTT). No correlation was found between these variables and the presence of SALs. Nevertheless, these variables may not be the best indications for the severity of laryngomalacia. Video scores were not found to correlate with clinical severity in a previous study of ours [26]. FTT has been reported in infants with laryngomalacia. A review and case report of surgical treatment with resolution of pectus excavatum, Arch. Otolaryngol. 110 (1984) 546–551.

In summary, we conclude that the rate of SALs in infants with congenital stridor due to laryngomalacia is low and most of the additional lesions are benign and do not have significant clinical or therapeutic implications. Hence, the yield of discovering clinically significant SALs below the glottic level is low. Added bronchoscopy appears to be warranted as a routine procedure and should be undertaken only in selective cases such as when neuromuscular conditions are present, or when there are additional clinical indicators to suggest the presence of a clinically meaningful associated lower airway lesion. We have actually adopted this policy after the completion of this study.

Specifically designed prospective studies may be necessary to characterize risk factors for the existence of SALs. This was not an industry-supported study.

Conflict of interest

All authors have indicated no financial conflicts of interest with this study.

References


