Research Square

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Risk factors for reoperation and postoperative tracheostomy after supraglottoplasty in children with laryngomalacia

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Abstract

Purpose

Laryngomalacia is the most common cause of congenital stridor in infants. Although supraglottoplasty is the standard surgical treatment for severe cases, some patients require reoperation or tracheostomy. This study aimed to evaluate the surgical outcomes of supraglottoplasty using microlaryngoscopic techniques and identify the risk factors for reoperation and postoperative tracheostomy.

Methods

We retrospectively reviewed children diagnosed with laryngomalacia who underwent supraglottoplasty at Shizuoka Children's Hospital between January 2008 and December 2024. Of 77 patients who underwent surgery, 65 patients with complete records were included in the analysis. The patient characteristics, comorbidities, and surgical outcomes were evaluated. The risk factors for reoperation and postoperative tracheostomy were analyzed using univariate and multivariate logistic regression analyses.

Results

Among the 65 patients, 38 were male and 27 were female, with a median age at surgery of 10 months. The Olney classifications were as follows: type I (n = 29; 44.6%) type II (n = 5; 7.7%), type III (n = 10; 15.4%), and combined-type laryngomalacia (n = 21; 32.3%). Reoperation was required in 21 patients (32.3%), and postoperative tracheostomy was performed in 7 patients (10.8%). In the univariate analysis, age ≤ 1 month, body weight ≤ 4 kg, and reoperation were significantly associated with postoperative tracheostomy; however, no factors were significant in the multivariate analysis. In the multivariate analysis for reoperation, combined-type laryngomalacia and airway comorbidities were identified as independent risk factors.

Conclusion

Supraglottoplasty is an effective surgical treatment for severe laryngomalacia. Combined-type laryngomalacia and airway comorbidities were associated with an increased risk of reoperation. Careful patient selection and perioperative management are therefore important to optimize surgical outcomes.

Introduction

Laryngomalacia is the most common cause of stridor in newborns and infants [1, 2], accounting for 45–75% of congenital stridor in infants [1, 3]. Most infants with laryngomalacia have mild symptoms and a benign disease course that resolves by 12–24 months of age; however, it is important to recognize that

not all cases of laryngomalacia have a benign course [1]. The pathophysiology of laryngomalacia is thought to involve abnormal neuromuscular control of the larynx [4]. Mild laryngomalacia is characterized by inspiratory stridor without other symptoms, whereas moderate laryngomalacia is associated with cough, regurgitation, choking, and feeding difficulties. Severe laryngomalacia may be associated with apneic episodes and cyanosis, growth failure, pectus excavatum, pulmonary hypertension, and cor pulmonale [3, 4].

The most common endoscopic findings are an inward collapse of the arytenoid mucosa (type I), medial displacement of the aryepiglottic folds (type II) and posterocaudal displacement of the epiglottis against the posterior pharyngeal wall (type III). [5]

In most cases, the symptoms improve with conservative management alone. However, in severe cases, poor feeding, failure to gain weight, severe respiratory distress, and obstructive apnea may occur, and tracheotomy or endotracheal intubation may be required [1].

Supraglottoplasty is the standard surgical treatment for severe laryngomalacia. Since 2008, we have performed supraglottoplasty using microlaryngoscopic techniques to avoid or wean off tracheostomy. However, some patients require repeated surgical intervention or ultimately undergo tracheostomy after surgery.

The aim of this study was to evaluate the surgical outcomes of supraglottoplasty using microlaryngoscopic techniques in children with laryngomalacia and to identify the risk factors for reoperation and postoperative tracheostomy.

Methods

Patient selection

This retrospective cohort study was conducted at Shizuoka Children's Hospital. We reviewed the medical records of all consecutive children diagnosed with laryngomalacia who underwent airway endoscopic evaluation between January 2008 and December 2024. During the study period, 188 children were diagnosed with laryngomalacia, of whom 77 underwent supraglottoplasty for severe symptoms. After excluding any patients with incomplete operative or follow-up records, 65 children were included in the final analysis.

The indications for surgery were the presence of severe laryngomalacia causing clinically significant airway or feeding problems, including persistent respiratory distress, recurrent cyanotic or apneic episodes, failure to thrive, feeding difficulty requiring intensive support, prolonged endotracheal intubation, or the need to avoid or wean from tracheostomy. Patients with mild symptoms who improved with conservative management were not included in the surgical cohort (Fig. 1).

This study was approved by the institutional ethics committee of Shizuoka Children's Hospital (approval number: 2024052). Owing to the retrospective nature of the study, the requirement for informed consent was waived in accordance with institutional policy.

Data collection

The following variables were collected from the medical records: sex, age at surgery, body weight at surgery, gestational age at birth, laryngomalacia type, history of tracheostomy, number of supraglottoplasty procedures, postoperative tracheostomy, and comorbid conditions.

Laryngomalacia was classified according to the Olney classification as type I, type II, type III, or combined-type. Comorbidities were grouped as glossoptosis, airway comorbidities, cardiac disease, neurological disease, chromosomal abnormalities.

Airway comorbidities were defined as additional structural or functional airway abnormalities identified on laryngotracheobronchoscopy and considered potentially relevant to persistent airway obstruction. Because this was a retrospective review over a long study period, the exact spectrum of airway lesions was not analyzed separately in the present study; instead, they were treated as a composite variable for the risk-factor analysis.

Operative methods

Representative procedures are shown in Fig. 2. All patients underwent supraglottoplasty under general anesthesia using microlaryngoscopic techniques with cold instruments. The surgical procedure was tailored to the endoscopic morphology of laryngomalacia.

For type I laryngomalacia, redundant arytenoid mucosa was excised and hemostasis was achieved using epinephrine-soaked cotton pledgets. For type II laryngomalacia, the shortened aryepiglottic folds were divided with laryngeal scissors, and redundant mucosa was removed when necessary. For type III laryngomalacia, epiglottopexy was performed by suspending the epiglottis to the tongue base using 3 – 0 absorbable sutures. In selected reoperative cases with recurrent posterior prolapse of the epiglottis, the mucosa on the lingual surface of the epiglottis and the tongue base was gently abraded before repeat suspension to promote adhesion.

Outcomes

The primary outcomes of this study were a reoperation after the initial supraglottoplasty and postoperative tracheostomy.

A reoperation was defined as any additional supraglottoplasty or laryngeal procedure performed for persistent or recurrent symptoms attributable to residual supraglottic collapse after the initial surgery.

Postoperative tracheostomy was defined as tracheostomy performed after the initial supraglottoplasty due to persistent or worsening upper airway obstruction, extubation failure, or the need for long-term airway stabilization.

To evaluate risk factors for postoperative tracheostomy, patients who had already undergone tracheostomy before the initial supraglottoplasty were excluded from that specific analysis. To evaluate the risk factors for reoperation, all included patients were analyzed.

Statistical analysis

Statistical analyses were performed using the JMP software program (ver. 18.01; SAS Institute, Inc, Cary, NC, USA). Frequencies and percentages were used to describe the categorical data. The chi-square test and Fisher's exact test were used to analyze the categorical data. The median and interquartile ranges were used to describe continuous variables. The Mann–Whitney *U* test and an analysis of variance were used to compare continuous variables. Multiple logistic regression analyses were performed using variables that were significant in the univariate analysis and were considered clinically relevant without strong multicollinearity. Baseline variables included sex, age at surgery, body weight at surgery, gestational age in weeks, types of laryngomalacia (type 1, type 2, type 3, combined-type), number of surgeries, tracheostomy after operation, and comorbidities (glossoptosis, airway comorbidities, cardiac disease, neurological disease, other). Numerical data were divided into two groups based on a cutoff value determined using a receiver operating characteristic (ROC) curve. Given the limited number of outcome events, the multivariate analyses and ROC-derived cutoff values were interpreted as exploratory. P values < 0.05 were considered statistically significant.

Results

Clinical characteristics

The clinical characteristics of the patients are summarized in Table 1. The median follow-up period was 40 months (range, 2–192 months). Among the 65 patients, 38 were male and 27 were female. The median age at the initial surgery was 10 months (range, 0–200 months). The median gestational age was 38 weeks (range, 23–41 weeks).

Table 1
Clinical characteristics of patients who underwent supraglottoplasty for laryngomalacia

Variable	Value
Follow-up period, months, median (range)	40 (2–192)
Age at first surgery, months, median (range)	10 (0–200)
Male sex, n (%)	38 (58.5)
Gestational age, weeks, median (range)	38 (23–41)
Olney classification, n (%)	
Type I	29 (44.6)
Type II	5 (7.7)
Type III	10 (15.4)
Combined type	21 (32.3)
Tracheostomy, n (%)	
Present before surgery	10 (15.4)
Decannulated	9 (13.8)
Postoperative tracheostomy	7 (10.8)
Glossoptosis, n (%)	42 (64.6)
Airway comorbidities, n (%)	43 (66.2)
Other associated conditions, n (%)	35 (53.8)
Cardiac disease	19 (29.2)
Chromosomal abnormalities	12 (18.5)

According to the Olney classification, 29 patients (44.6%) were classified as type I, 5 (7.7%) as type II, 10 (15.4%) as type III, and 21 (32.3%) as combined-type. Reoperation was required in 21 patients (32.3%). Postoperative tracheostomy was performed in 7 patients (10.8%).

Glossoptosis was observed in 42 patients (64.6%), airway comorbidities in 43 (66.2%), and other associated conditions in 35 (53.8%).

Risk factors for reoperation

The risk factors for reoperation were analyzed in all 65 patients. The patients were divided into two groups: those who underwent a single surgery (S group, n = 44) and those who required multiple

surgeries (M group, n = 21). The following variables were analyzed: age at surgery ≤ 1 month, body weight at surgery ≤ 4 kg, combined-type laryngomalacia, glossoptosis, airway comorbidities, congenital heart disease, and chromosomal abnormalities. In the univariate analysis, age at surgery ≤ 1 month (odds ratio [OR] 3.91, p = 0.04), body weight at surgery ≤ 4 kg (crude OR 4.82, p = 0.01), and airway comorbidities (crude OR 5.48, p < 0.01) were significantly associated with reoperation (Table 2).

Table 2
Comparison of clinical characteristics between patients undergoing single and multiple surgeries

Variable	S (n = 44)	M (n = 21)
Age at surgery < 1 month, n (%)	3 (6.8)	1 (4.7)
Body weight at surgery < 4 kg, n (%)	6 (13.6)	10 (47.6)
Combined-type laryngomalacia, n (%)	17 (38.6)	4 (19.0)
Glossoptosis, n (%)	26 (59.0)	16 (76.1)
Airway comorbidities, n (%)	24 (54.5)	17 (80.0)
Cardiac comorbidity, n (%)	14 (31.8)	5 (23.8)
Chromosomal abnormalities, n (%)	11 (25.0)	1 (4.7)
S, single operation; M, multiple operations.		

In the multivariate analysis, combined-type laryngomalacia (adjusted OR 7.59, p = 0.04)

and airway comorbidities (adjusted OR 6.86, p < 0.01) were identified as independent risk factors for reoperation (Table 3).

Table 3
Univariate and multivariate analyses of risk factors for reoperation after supraglottoplasty

Variable	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age at surgery < 1 month	3.91 (1.06–14.31)	0.04	4.56 (0.28–73.57)	0.26
Body weight at surgery < 4 kg	4.82 (1.48–15.59)	0.01	6.64 (1.01–49.11)	0.05
Combined-type laryngomalacia	2.68 (0.92–9.31)	0.06	7.59 (1.03–73.3)	0.04
Glossoptosis	2.22 (0.69–7.14)	0.15	–	–
Airway comorbidity	5.48 (1.41–21.29)	< 0.01	6.86 (1.32–35.67)	< 0.01
Cardiac comorbidity	1.16 (0.37–3.64)	0.79	–	–
Chromosomal abnormalities	1.49 (0.48–4.67)	0.48	–	–
OR odds ratio, CI confidence interval.				

Risk factors for postoperative tracheostomy

A receiver operating characteristic (ROC) curve analysis was performed to determine the optimal cutoff values for age and body weight at surgery for predicting postoperative tracheostomy. The optimal cutoff values were 1 month for age [area under the curve (AUC), 0.68] and 4 kg for body weight (AUC, 0.78). These values were subsequently used as cutoff points in the univariate and multivariate analyses.

The risk factors for postoperative tracheostomy were analyzed in 55 patients who had not undergone tracheostomy at the time of the initial surgery (Fig. 3). In the univariate analysis, age at surgery ≤ 1 month (crude OR 6.67, p = 0.02), body weight at surgery ≤ 4 kg (crude OR 7.50, p = 0.02), and reoperation (crude OR 6.73, p = 0.03) were significantly associated with postoperative tracheostomy (Table 4). However, in the multivariate analysis, age at surgery ≤ 1 month (adjusted OR 2.28, p = 0.49), body weight at surgery ≤ 4 kg (adjusted OR 2.72, p = 0.42), and reoperation (adjusted OR 3.98, p = 0.15) were not identified as significant risk factors (Table 5).

Table 4
Comparison of clinical characteristics between patients with and without postoperative tracheostomy

Variable	No postoperative tracheostomy (n = 48)	Postoperative tracheostomy (n = 7)
Age at surgery < 1 month, n (%)	4 (8.3)	4 (57.1)
Body weight at surgery < 4 kg, n (%)	12 (25.0)	3 (42.8)
Combined-type laryngomalacia, n (%)	18 (37.5)	3 (42.8)
Glossoptosis, n (%)	28 (58.3)	6 (85.7)
Airway comorbidity, n (%)	27 (56.2)	5 (71.4)
Reoperation, n (%)	13 (27.0)	5 (71.4)
Cardiac comorbidity, n (%)	14 (29.1)	2 (28.5)
Chromosomal abnormalities, n (%)	8 (16.6)	1 (14.2)

Table 5
Univariate and multivariate analyses of risk factors for postoperative tracheostomy

Variable	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age at surgery < 1 month	6.67 (1.24–35.71)	0.02	2.28 (0.21–34.21)	0.49
Body weight at surgery < 4 kg	7.50 (1.28–43.82)	0.02	2.72 (0.27–34.27)	0.42
Combined-type laryngomalacia	1.25 (0.25–6.23)	0.78	–	–
Glossoptosis	4.28 (0.48–38.42)	0.19	–	–
Airway comorbidity	1.78 (0.32–10.15)	0.51	–	–
Reoperation	6.73 (1.15–39.08)	0.03	3.98 (0.59–26.63)	0.15
Cardiac comorbidity	1.82 (0.36–9.21)	0.46	–	–
Chromosomal abnormalities	2.47 (0.27–22.44)	0.42	–	–

OR odds ratio, CI confidence interval.

Discussion

The most clinically important finding of the present study was that children with combined-type laryngomalacia and associated airway abnormalities frequently required repeated surgical intervention despite undergoing supraglottoplasty. In the multivariate analysis, combined-type laryngomalacia and airway comorbidities were identified as independent risk factors for reoperation. These findings suggest that patients with a complex airway morphology or associated airway abnormalities are more likely to experience persistent symptoms after the initial surgery and may require a reoperation.

Airway comorbidities may contribute to persistent airway obstruction and reduce the effectiveness of supraglottoplasty. Previous studies have also suggested that synchronous airway lesions are associated with poorer surgical outcomes in patients with laryngomalacia [6, 7]. In our cohort, airway comorbidities were present in 66.2% of patients, suggesting that coexisting airway lesions are relatively common in children with laryngomalacia who require surgical treatment. Therefore, a careful preoperative airway evaluation is essential when planning supraglottoplasty, and the presence of associated airway abnormalities should be considered when predicting the postoperative outcomes. Recent international consensus recommendations have also emphasized the importance of a comprehensive airway assessment and individualized surgical planning in patients with severe laryngomalacia [8].

These findings are clinically important because recognition of these risk factors may strongly influence preoperative counseling, surgical planning, and perioperative airway management strategies. Therefore, careful perioperative evaluations and staged airway management may be particularly important in these high-risk patients.

Previous studies and systematic reviews have reported favorable outcomes after supraglottoplasty, with success rates ranging from 70% to 100% [6, 9–11]. In the present study, a reoperation was required in 21 of 65 patients (32.3%). The relatively high reoperation rate likely reflects the severe and complex nature of the study population, as all included patients required surgical intervention at a tertiary pediatric center and many had associated airway abnormalities or glossoptosis.

Although some patients required a reoperation, repeated supraglottoplasty may still contribute to avoiding tracheostomy in selected patients with severe airway obstruction. In the present study, all included patients had severe symptoms requiring surgical intervention, and many patients were managed without tracheostomy despite requiring multiple procedures.

Tracheostomy in infants and children is associated with substantial morbidity, including recurrent respiratory infections, speech and swallowing difficulties, an impaired quality of life, and a significant caregiver burden [12, 13]. Pediatric tracheostomy is also associated with repeated hospitalizations, a risk of accidental decannulation, delayed speech development, and a long-term home-care burden for caregivers. Therefore, avoidance of tracheostomy whenever safely possible is an important therapeutic goal in the management of severe laryngomalacia.

With regard to postoperative tracheostomy, a younger age and lower body weight were associated with tracheostomy in the univariate analysis, although no independent risk factors were identified in the multivariate analysis. These findings suggest that infants with an immature airway anatomy and low body weight may have more severe airway obstruction and require careful perioperative management. Because of the limited number of postoperative tracheostomy events, the multivariate analysis may have been underpowered, and these findings should therefore be interpreted cautiously.

The natural course of laryngomalacia is generally benign, and many patients can be managed conservatively [1, 3]. However, previous studies have demonstrated that supraglottoplasty results in a faster symptom resolution in comparison to conservative management in patients with severe symptoms [14]. These findings support the role of surgical intervention in selected patients with significant airway obstruction.

Our findings are also consistent with previous reports from Japan describing the surgical management of upper airway obstruction in infants [15]. These studies suggest that appropriate surgical intervention may help avoid tracheostomy in selected patients with severe airway obstruction.

This study has several limitations. First, this was a retrospective single-center study with a relatively small sample size. Second, the surgical indications and perioperative management strategies may have changed during the long study period. Third, because the study population was limited to patients who underwent surgical treatment, the results may not be generalizable to all patients with laryngomalacia.

In conclusion, supraglottoplasty is an effective treatment for severe laryngomalacia. Combined-type laryngomalacia and airway comorbidities were identified as risk factors for reoperation, while a younger

age and lower body weight may be associated with postoperative tracheostomy. Careful patient selection and comprehensive airway evaluation are essential to optimize the surgical outcomes. Even in patients requiring reoperation, repeated supraglottoplasty may contribute to avoiding tracheostomy in selected patients with severe airway obstruction.

Declarations

Ethics approval and consent to participate

This study was approved by the institutional ethics committee of Shizuoka Children's Hospital (approval number: 2024052). Owing to the retrospective nature of the study, the requirement for informed consent was waived.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

YS conceived the study, collected and analyzed the data, participated in the surgical management of the patients, and drafted the manuscript. MY participated in the surgical management of the patients, performed the statistical analyses, and critically revised the manuscript. KF, HM, AN, YG, and YY participated in the surgical management of the patients and contributed to data collection and interpretation. All authors read and approved the final manuscript.

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Availability of data and materials:

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figures

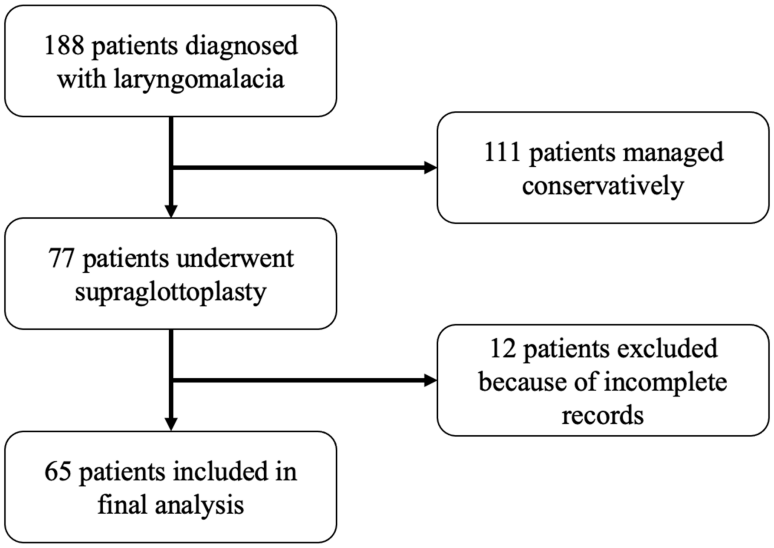


Figure 1

Flowchart of patient selection.

During the study period, 188 children were diagnosed with laryngomalacia. Among them, 77 patients underwent supraglottoplasty for severe symptoms. After the exclusion of 12 patients because of incomplete operative or follow-up records, 65 patients were included in the final analysis.

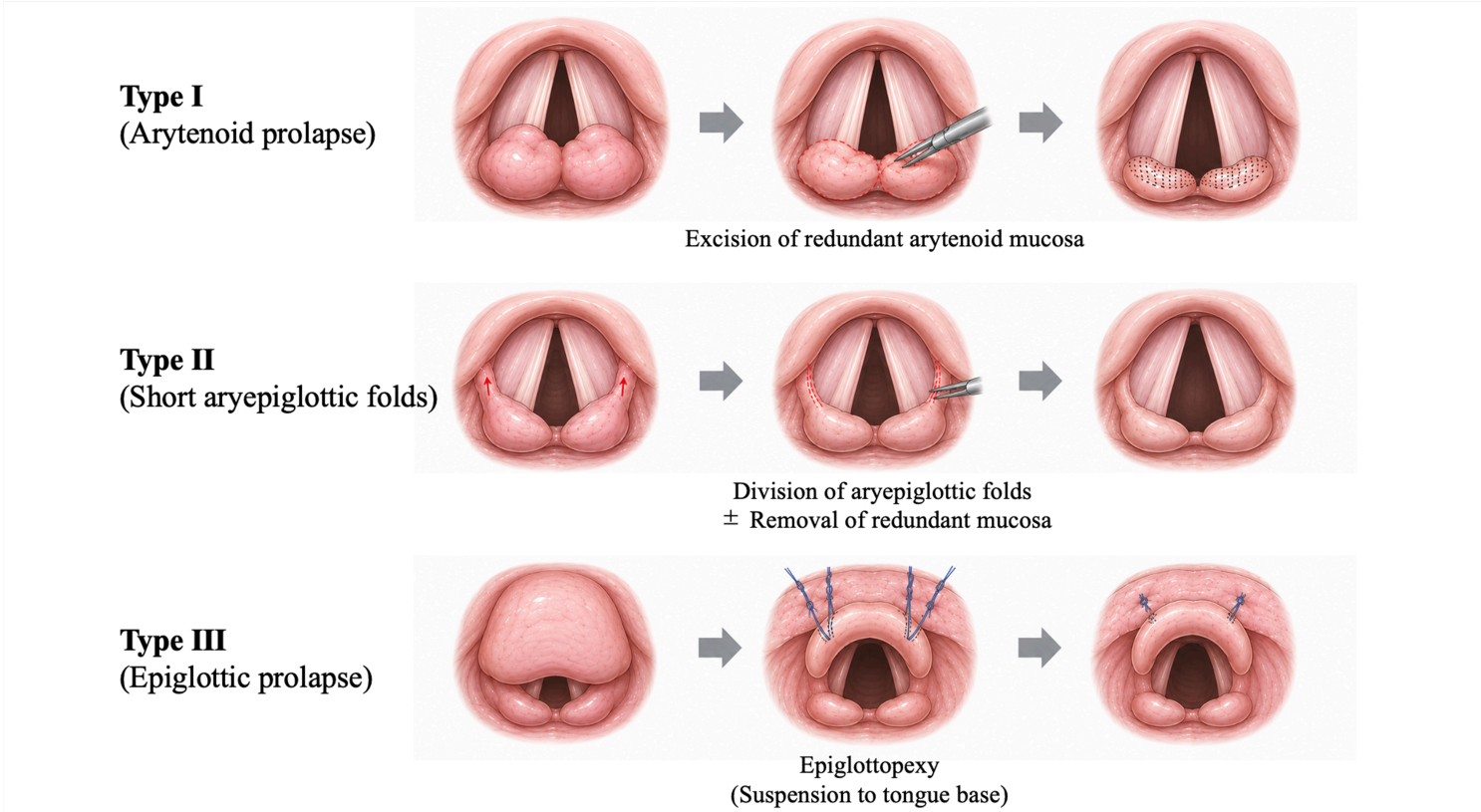


Figure 2

Representative surgical procedures according to laryngomalacia type.

Representative endoscopic views of supraglottoplasty performed using microlaryngoscopic techniques. Type I laryngomalacia was treated by excision of redundant arytenoid mucosa. Type II laryngomalacia was treated by division of the aryepiglottic folds with or without removal of redundant mucosa. Type III laryngomalacia was treated by epiglottopexy with the suspension of the epiglottis to the tongue base.

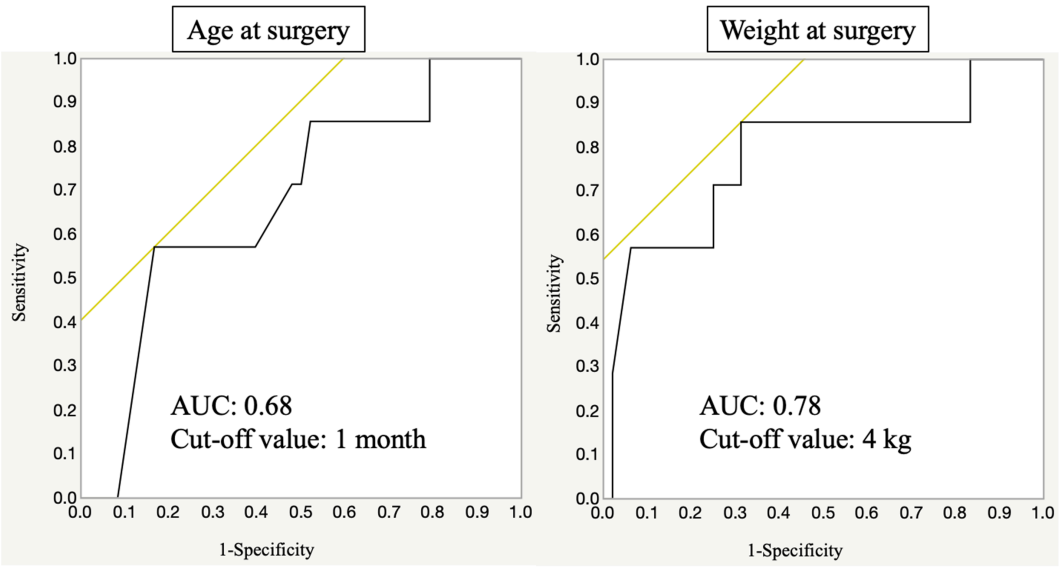


Figure 3

A receiver operating characteristic (ROC) curve analysis for postoperative tracheostomy.

A receiver operating characteristic (ROC) curve analysis was performed to determine the optimal cutoff values for age and body weight at surgery for predicting postoperative tracheostomy. The optimal cutoff values were 1 month for age at surgery (AUC = 0.68) and 4 kg for body weight at surgery (AUC = 0.78).