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Original Article

Flexible bronchoscopic findings and the relationship to repeated extubation failure in critical children

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Abstract

Background: Extubation failure (EF) in acute pediatric cases causes high morbidity and prolonged hospitalization, some of which might encounter EF repeatedly. This study aims to investigate flexible bronchoscopic findings of airway problems associated with repeated EF (REF) in children.

Methods: We retrospectively reviewed the medical records of intubated children from 2005 to 2013 and enrolled those with EF (reintubated within 48 h after extubation) and receiving flexible bronchoscopy (FB) examinations. We divided all subjects into two groups, the REF group (reintubated within 48 h after FB examination) and control group (no need of reintubation), and compared the related clinical conditions and outcomes.

Results: We assessed 30 children (REF group, 17 cases; control group, 13 cases). Among them, no significant difference was observed in age, weight, and underlying diseases. In the REF group, the outpatient ratio, tracheostomy rate, intubation days, respiratory or oxygen supported days, and EF episodes were significantly higher than the control group ($p < 0.05$). Moreover, the FB findings in the REF group exhibited higher ratios of all airway problems and significantly in the presence of upper airway granulations (odds ratio [OR], 17.9, 95% confidence interval [CI]: 2.7−116.9) and subglottic stenosis (OR, 5.4; 95% CI: 1.1−26.0). After discharge, subjects of the REF group required higher medications than those in the control group (OR, 81.0; 95% CI: 3.9−1655.8).

Conclusion: Upper airway granulations or stenosis significantly augment the risk of REF in children; however, these could be diagnosed early by FB, guiding the therapeutic protocol in acute cases. Thus, anatomical problems of upper airways should be considered in intubated children with EF, and FB is a useful tool for the early diagnosis and management.

Keywords: Children; Extubation failure; Flexible bronchoscopy; Granulation; Intensive care; Subglottic stenosis

1. Introduction

Mechanical ventilation (MV) is a life-saving tool commonly used in pediatric and neonatal intensive care units (ICUs). Pediatric patients with different forms of respiratory failure receive effective airway support from endotracheal tube (ETT) intubations. Patients are typically weaned from MV as they resume spontaneous breathing. MV has been associated

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with several adverse effects, including ventilation-induced lung injury and nosocomial infection, and the positive pressure ventilation (PPV) might cause interactions between the heart and lungs.[1] Thus, shortening the duration of invasive ventilation is imperative. However, patients often require reintubation for adequate respiratory supports within 24−48 h after extubation failure (EF).[2] Reportedly, children with EF have longer hospital and ICU stays, undergo more courses on a ventilator,[3−5] exhibit a longer post-extubation intubation time, a higher mortality rate, and higher hospitalization costs than those without extubation.[2−4,6,7] Moreover, noninvasive ventilation is reportedly used after extubation to reduce the occurrence rate of EF.[1,8]

Little children might encounter EF repeatedly[9]; these repeated EFs (REFs) increase the suffering of children and increases the risk of morbidity. Thus, determining and preventing factors associated with EF and REF are essential in treating acute pediatric cases.

EF is defined as the replacement of an ETT within <48 h after extubation.[2] Reportedly, the incidence of EF is estimated to be 22%−28% in infants and 16%−19% in children; overall, 30%−40% of extremely preterm infants require ETT replacement within 1 week of extubation.[10−13] Lately, several studies have investigated the risk factors and reasons for EF among critically ill children. Reportedly, the risk factors associated with pediatric EF are age younger than 24 months, dysgenetic conditions, syndromic conditions, chronic respiratory and neurological conditions, medical or surgical airway condition, prolonged intubation duration, the mean oxygen index >5, and an MV duration >15 days.[3] Research has established the upper airway obstruction as the leading cause of EF,[1,3,5] necessitating a prompt and precise diagnosis for the adequate management of children with EF to prevent further REF.

In the evaluation of airway disease in children, bronchoscopy facilitates both diagnostic and interventional procedures.[14] Flexible bronchoscopy (FB) is a safe and valuable diagnostic tool for the anatomical airway problems in pediatric ICUs.[15−17] Moreover, therapeutic interventions with FB efficiently relieve airway problems,[15−17] highlighting the potential benefits of applying FB to children with EF. Although the use of FB has been suggested in preterm infants with REF,[9] reports regarding bronchoscopic findings in children with EF are rare. Therefore, comprehensive investigation of airway problems and their relationship to REF in children is mandatory. We hypothesized that airway problems could be diagnosed by FB in REF children. This study aims to investigate FB findings and the related factors to REF in acute pediatric cases.

2. Methods

2.1. Study subjects

We retrospectively reviewed the medical records of all intubated children admitted between January 2005 and December 2013 in the pediatric ICU of a tertiary medical center. In our medical center, the care protocol for children with EF comprised performing FB to assess airway problems if an attending physician judged that a patient was not ready to be extubated 24−48 h after the last reintubation. This study was approved by the Institutional Review Board of Taipei Veterans General Hospital (approval number: VGHIRB2014-11-007A).

The inclusion criteria were as follows: younger than 18 years, experienced EF and requiring reintubation with MV for >24 h, and examined by FB after that episode. We defined EF as the ETT replacement within <48 h after extubation. Conversely, the exclusion criteria were that children had already undergone tracheostomy before the MV of that hospitalization. We divided all enrolled subjects into two groups as follows: (a) REF group, subjects required reintubation after the FB examination within <48 h and (b) control group, subjects required no further intubation after the FB examination.

Data of subjects comprised the following five aspects: (1) demographic variables: children's age, weight, gender, transfer from another hospital, EF episodes before the initial FB examination, total EF episodes, time to reintubation, and etiologies of EF before initial FB examination. (2) Variables associated with patients' diseases: major underlying diseases and respiratory complications. (3) Requirement for the clinical management during hospitalization: total intubation days, intubation days before the initial FB examination, duration of invasive MV (IMV) days, duration of noninvasive PPV (NIPPV) days, respiratory and oxygen requirement days, hospital stay, total ICU stay, ICU readmission rate, tracheostomy rate, requirement for inhaled nitric oxide (iNO), requirement for extracorporeal membrane oxygenation (ECMO), requirement for use of surfactant, and requirement for high-frequency oscillatory ventilation (HFOV). In this study, some children had been transferred from other hospitals and their medical records were collected from the referring hospital; these included intubation days, duration of IMV and NIPPV days, EF episodes, hospital stay, total ICU stay, and any requirement for special intervention (iNO, ECMO, surfactant, and HFOV). We defined respiratory and oxygen requirement days as the total IMV, NIPPV, and supplemental oxygen days required during the patients' complete hospitalization. (4) The outcome of the FB examination: we collected and analyzed all FB procedures and reports. (5) The outcome at discharge: hospital death or survival, requirement for transfer to a long-term facility or for respiratory or oxygen support at discharge.

2.2. Procedures of FB

FB was first performed using a 3.0-mm external diameter with a 30-cm working length without a working channel and was introduced through the ETT to assess the airway below the ETT tip. If the internal diameter of ETT were <3.0 mm, FB would be performed using a 2.2-mm external diameter with a 60-cm working channel. Following the initial FB examination, the trial of extubation was performed, and the FB

was introduced through patients' nostril tract to assess their upper and lower airways. Each FB session comprised several scope insertions as mentioned earlier.

A positive finding and the requirement of therapeutic interventions implied that the therapeutic instruments, such as flexible laser fiber and small forceps, would be passed through the working channel of FB or instruments (balloon catheter and large forceps) were used alongside FB in patients' airway lumen.

Of note, subjects might have required more than one FB examination and/or multiple interventional procedures depending on their FB findings and clinical conditions after that.

2.3. Statistical analysis

Continuous variables are presented as medians with interquartile range (IQR) because of non-normality of the data. We used the Mann–Whitney *U*-test to analyze the continuous data between groups and the χ^2 or the Fisher's exact test for categorical variables. Furthermore, odds ratios (ORs) and 95% confidence interval (CI) were evaluated for factors associated with the poor outcome of REF and the medical care requirements after discharge. Furthermore, we considered $p < 0.05$ as statistically significant.

3. Results

During the 8-year study period, we enrolled 30 children (14 men and 16 women; median age, 4 months; median weight, 4.7 kg; Table 1) in this study. The REF and control group had 17 (56.7%) and 13 (43.3%) children, respectively.

A majority of children were younger than 24 months (27; 90%) when they received FB examinations, and the highest age group was 0–5 months (Fig. 1). In both groups, no significant difference was observed in age, body weight, gender, and the episodes before FB. In the REF group, most children were transferred from other hospitals (15; 88.2%), which was significantly higher than the control group ($p = 0.049$).

In this study, the most common respiratory problem was pneumonia (23; 76.7%), and cardiac disease (18; 60%) was the most common extrapulmonary underlying disease, which included two children with cyanotic heart disease (Tetralogy of Fallot and transposition of vessels). We observed no significant difference in children's age, body weight, gender, EF episodes before the initial FB examination, underlying diseases, and respiratory complications between both groups (Table 1).

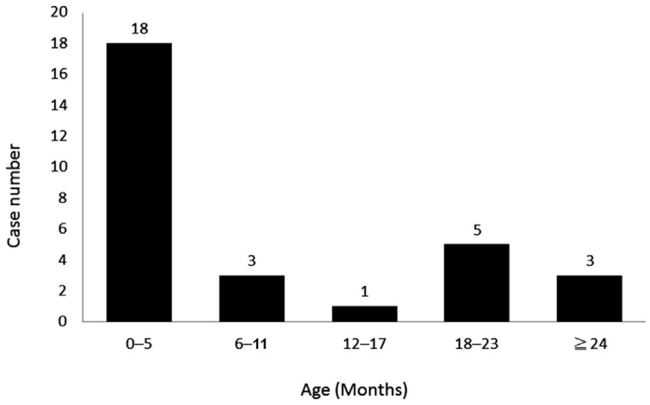

Fig. 1. The age distribution of all 30 children who experienced extubation failure for, at least, once and underwent flexible bronchoscopic examinations.

Table 1
Characteristics of all enrolled children and the comparisons between two groups.

	Total ($n = 30$)	REF ($n = 17$)	Control ($n = 13$)	p[c]
Patients' demographics				
Age (month)[a]	4 (2–19)	4 (3–17)	3 (1.0–20)	0.432
Body weight (kg)[a]	4.7 (2.9–8.2)	4.3 (2.9–8.7)	5.6 (2.8–7.5)	0.934
Male, *n* (%)	14 (46.7)	7 (41.2)	7 (53.8)	0.491
Out-patients, *n* (%)	22 (73.3)	15 (88.2)	7 (53.8)	0.049
EF episodes before the initial FB examination[a]	1 (1–3)	2 (1–3)	1 (1–2.5)	0.408
Underlying diseases				
Respiratory diseases				
Pneumonia, *n* (%)	23 (76.7)	15 (88.2)	8 (61.5)	0.190
Respiratory distress syndrome, *n* (%)	10 (33.3)	5 (29.4)	5 (38.5)	0.705
Lung atelectasis, *n* (%)	10 (33.3)	5 (29.4)	5 (38.5)	0.705
Pneumothorax, *n* (%)	4 (13.3)	3 (17.6)	1 (7.7)	0.613
Pulmonary hypertension, *n* (%)	4 (13.3)	3 (17.6)	1 (7.7)	0.613
Cardiac disease, *n* (%)	18 (60)	10 (58.8)	8 (61.5)	0.880
Cyanotic, *n* (%)	2 (6.7)	0 (0)	2 (15.4)	0.176
Non-cyanotic, *n* (%)	16 (53.3)	10 (58.8)	6 (46.2)	0.491
Prematurity, *n* (%)	15 (50)	9 (52.9)	6 (46.2)	0.713
Neurological disease, *n* (%)	8 (26.7)	5 (29.4)	3 (23.1)	1.000
Gastrointestinal disease, *n* (%)	6 (20)	5 (29.4)	1 (7.7)	0.196
Other diseases[b], *n* (%)	7 (23.3)	4 (23.5)	3 (23.1)	1.000

EF = extubation failure; FB = flexible bronchoscopy; REF = repeated extubation failure.
[a] Data are median (interquartile range).
[b] biliary atresia, renal failure, inguinal hernia, imperforated anus, septic shock, and congenital hypothyroidism.
[c] Comparisons between REF and control groups.

Table 2 presents the requirement for the clinical management during hospitalization. The REF group exhibited significantly longer total intubation days, more requirement for respiratory and/or oxygen support days, total EF episodes, and requirements for tracheostomy than the control group ($p < 0.05$). All six cases requiring tracheostomy were in the REF group and attributed to vocal cord palsy with severe subglottic stenosis ($n = 4$), severe subglottic stenosis with compromised airway ($n = 1$), and peripheral neuropathy disease ($n = 1$). Furthermore, no statistically significant differences were observed in the duration of intubation before FB, special respiratory interventions, duration of NIPPV, length of ICU stays, length of total hospital stay, and ICU readmission rate between both (Table 2).

Table 3 shows FB findings of the study cohort; airway stenosis (23; 76.7%), including nasal tract stenosis, subglottic stenosis, and tracheobronchial stenosis, was the most common finding. Airway granulations (13, 76.5%), including vocal cord granulations and tracheobronchial granulations, were significantly more common in the REF than the control group. The OR of airway granulation for developing REF was 7.3 (95% CI: 1.4–37.2; Table 3). Fig. 2 shows the representative photographs of children with vocal cord granulation and stenosis.

Regarding the lesion site of airways, 93.3% ($n = 28$) and 70% ($n = 21$) of children had upper and lower airway problems, respectively; 11 children (36.7%) had positive findings for both upper and lower airways. In upper airway, granulations (13; 76.5%) and subglottic stenosis (12; 70.6%) were significantly more common in the REF than the control group ($p = 0.001$ and 0.030, respectively). Overall, 10 children (33.3%) exhibited positive finding for both granulations and subglottic stenosis, 9 of which were in the REF group. Furthermore, five children (16.7%) had bilateral vocal cord palsy in the REF group; of these, two children exhibited neurogenic abnormalities and three required tracheostomy before discharge. For upper airway granulations and subglottic stenosis in developing REF, ORs were 17.9 (95% CI: 2.7–116.9) and 5.4 (95% CI: 1.1–26.0) for upper airway granulations and subglottic stenosis, respectively (Table 3). In lower airways, bronchomalacia (40%) was the most common finding, and we observed no significant differences between the two groups in their lower airway findings. Regarding cases with significant airway problems, therapeutic interventions were performed per the discretion of the examining physician. Notably, tracheal stent implantation ($n = 2$), tracheal stent repair ($n = 2$), balloon dilatation ($n = 1$), and laser therapy for laryngomalacia ($n = 2$) were applied in both the REF and control groups without significant difference. However, laser therapy for vocal cord granulations or stenosis was performed on nine children during hospitalization, who were extubated and discharged from our hospital. Furthermore, children in REF group required more frequency of FB examination with or without further intervention; thus, the FB frequency was significantly higher in the REF (median, 4; IQR: 2–8) than the control (median, 1; IQR: 1–3) group ($p < 0.001$; Table 2).

Table 4 shows comparisons of unfavorable outcomes at discharge. Most children in the REF group (76.5%) required medications at discharge (OR, 4.8; 95% CI: 2.4–942.4). However, all children in the control group were discharged without requiring medications, respiratory or oxygen support, transfer to respiratory care facilities, or in-hospital mortality. Notably, two patients died during hospitalization (6.7%) in the REF group (cerebellar tumor, 1; acute respiratory distress syndrome, 1).

4. Discussion

This study established a significant correlation between upper airway stenosis or granulations and the occurrence of

Table 2
Comparisons of the clinical Management during hospitalization between children with and without REF.

Clinical Managements	Total ($n = 30$)	REF ($n = 17$)	Control ($n = 13$)	p[c]
Duration of total intubation (days)[a]	40 (25–99)	76 (40–130)	25 (15–35)	0.001
Duration of intubation before FB (days)[a]	24 (16–63)	29 (20–99)	23 (13–33)	0.300
Special respiratory interventions				
Use of iNO, n (%)	2 (6.7)	2 (11.8)	0 (0)	0.492
Use of ECMO, n (%)	2 (6.7)	1 (5.9)	1 (7.7)	1.000
Use of Survanta, n (%)	8 (26.7)	5 (29.4)	3 (23.1)	1.000
Use of HFOV, n (%)	8 (26.7)	5 (29.4)	3 (23.1)	1.000
Duration of NIPPV (days)[a]	6 (0–25)	4 (0–31)	7 (2–24)	0.592
Duration of total respiratory and/or oxygen supports (days)[b]	71.5 (31–132.5)	94 (45–147)	40 (25–81)	0.020
Length of ICU stay (days)[a]	70 (41–117)	78 (51–143)	56 (29–85)	0.072
Length of total hospital stay (days)[a]	81 (40–139)	98 (53–176)	61 (31–93)	0.065
Tracheostomy, n (%)	6 (20)	6 (35.3)	0 (0)	0.024
ICU re-admission, n (%)	5 (16.7)	4 (23.5)	1 (7.7)	0.355
Total EF episodes	2 (1–4)	4 (2–5.5)	1 (1–0.5)	0.002

ECMO = extracorporeal membrane oxygenation; EF = extubation failure; FB = flexible bronchoscopy; HFOV = high-frequency oscillatory ventilation; ICU = intensive care unit; IMV = invasive mechanical ventilation; iNO = inhaled nitric oxide; NIPPV = noninvasive positive pressure ventilation; REF = repeated extubation failure.

[a] Data are median (interquartile range).

[b] Sum of overall IMV days, NIPPV days, and supplemental oxygen days during hospitalization.

[c] Comparisons between REF and control groups.

Table 3
Comparisons of FB findings between children with and without REF.

Findings	Total (n = 30)	REF (n = 17)	Control (n = 13)	p[a]	OR[b] (95% CI)
Summary of abnormal findings					
Airway stenosis	23 (76.7)	14 (82.4)	9 (69.2)	0.666	3.2 (0.7–14.6)
Airway malacia	19 (63.6)	13 (76.5)	6 (46.2)	0.132	3.8 (0.8–18.1)
Airway granulation	17 (56.7)	13 (76.5)	4 (30.8)	0.012	7.3 (1.4–37.2)
Esophageal problem	13 (43.3)	7 (41.2)	6 (46.2)	0.785	0.8 (0.2–3.5)
Findings at different sites					
Upper airway	28 (93.3)	17 (100)	11 (84.6)	0.179	
Subglottic stenosis	16 (53.3)	12 (70.6)	4 (30.8)	0.030	5.4 (1.1–26.0)
Granulations	15 (50)	13 (76.5)	2 (15.4)	0.001	17.9 (2.7–116.9)
Nasal tract stenosis	11 (36.7)	8 (47.1)	3 (23.1)	0.259	
Pharyngomalacia	6 (20)	3 (17.6)	3 (23.1)	1.000	
Laryngomalacia	8 (26.7)	5 (29.4)	3 (23.1)	1.000	
Vocal cord palsy	5 (16.7)	5 (29.4)	0 (0)	0.052	11.9 (0.6–237.6)
Cleft soft palate	1 (3.3)	1 (5.9)	0 (0)	1.000	
Lower airway	21 (70)	13 (76.5)	8 (61.5)	0.443	
Bronchomalacia	12 (40)	9 (52.9)	3 (23.1)	0.098	3.8 (0.8–18.6)
Tracheomalacia	7 (23.3)	4 (23.5)	3 (23.1)	1.000	
Granulations	6 (20)	5 (29.4)	1 (7.7)	0.196	
Tracheal stenosis	5 (16.7)	2 (11.8)	3 (23.1)	0.682	
Bronchial stenosis	5 (16.7)	2 (11.8)	3 (23.1)	0.682	
Trifurcation of carina	1 (3.3)	0 (0)	1 (7.7)	0.433	

Data are number of patients (percentage).
CI = confidence interval; FB = flexible bronchoscopy; OR = odds ratio; REF = repeated extubation failure.
[a] Comparisons of the ratios between REF and Control groups.
[b] Comparisons using REF as the bad outcome.

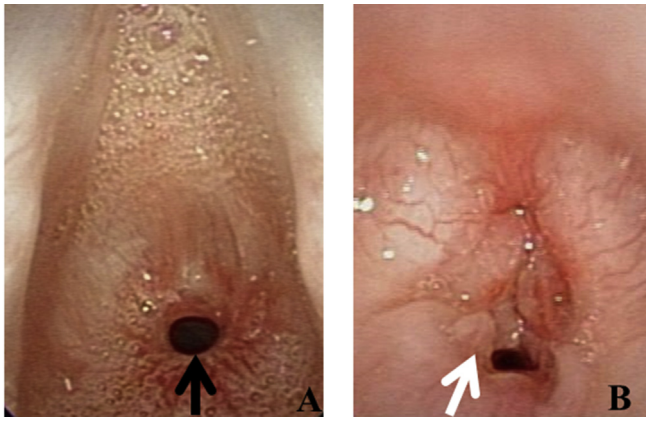

Fig. 2. Representative flexible bronchoscopic images in children with upper airway granulation and stenosis. A. Significant airway stenosis at the level of the vocal cord in a 3-month-old female infant. B. Large airway granulations at the vocal cord in a 4-month-old male infant.

REF in pediatric patients. Besides, FB examinations facilitated the early diagnosis and guide further management of airway problems in acute pediatric cases.

REF might result in severe outcomes in the pediatric population. The two major findings of our study regarding children with EF are as follows. First, the REF group exhibited more intubation days, MV days, respiratory and oxygen support days, and a higher tracheostomy rate. Second, vocal cord granulation and subglottic stenosis were common problems among the REF group children, in whom serial FB examinations and therapeutic interventions by FB were applied for such complicated issues, especially laser therapy for upper airway granulations or stenosis. Previously, we reported that FB could be safely and efficiently used for the diagnostic and invasive therapeutic purpose among patients in pediatric and neonatal ICUs. Over the years, various FB procedures have been successfully used in our ICUs.[15] For children with EF, this study further illustrated its utility and safety for the diagnostic purpose and a guide for following the therapeutic plan.

Baisch et al. reported a significantly higher tracheostomy rate and more intubation days in the EF pediatric population than in the successful extubation group.[5] Likewise, Fontela et al. established an association between a long duration of the ventilator support and EF (MV duration ≥15 days; OR, 6.36; 95% CI: 1.32–30.61).[18] Similarly, Gaies et al. reported that pediatric patients with reintubation received a longer duration of MV (MV duration ≥44.1 h; OR, 2.54; 95% CI: 1.14–5.64).[19] Moreover, Kurachek et al. reported that pediatric patients failing extubation exhibited a significantly longer pre-extubation intubation time (148.7 h).[3] Our results corroborate these previous studies although none has comprehensively investigated children with REF.

Reportedly, upper airway obstruction is the leading cause of EF in pediatric cases.[1,3] In our experience, FB can diagnose upper airway problems easily.[15] A study on preterm newborns with REF suggested that receiving bronchoscopy is probably necessary because of some airway anatomical alterations that explain the second occurrence of EF.[9] By performing direct laryngoscopy and bronchoscopy on premature infants to investigate the cause of EF, Pereira et al. reported that 44% of

Table 4
Comparisons of the unfavorable outcome at discharge between children with and without REF.

Outcome at Discharge	Total (n = 30)	REF (n = 17)	Control (n = 13)	p[a]	OR[b] (95% CI)
Discharged to home					
Requiring medications	11 (36.7)	11 (64.7)	0 (0)	<0.001	47.8 (2.4−942.4)
Requiring respiratory/oxygen supports[c]	6 (20)	6 (35.3)	0 (0)	0.024	15.2 (0.8−301.1)
Transferred to long-term respiratory care facilities	5 (16.7)	5 (29.4)	0 (0)	0.052	11.9 (0.6−237.6)
In-hospital mortality	2 (6.7)	2 (11.8)	0 (0)	0.492	

Data are number of subjects (percentage).
CI = confidence interval; OR = odds ratio; REF = repeated extubation failure.
[a] Comparisons of the ratios between REF and Control groups.
[b] ORs of REF for the unfavorable outcomes at discharge.
[c] Including invasive and noninvasive ventilation.

EF subjects had subglottic stenosis and edema.[20] Regarding upper airway problems and EF, FB provided positive findings in acute cases. Manna et al. reported that FB in children with EF detected five with multifactorial upper airway obstruction, five with laryngeal edema, two with subglottic granuloma, two with tracheobronchomalacia, three with vascular compression trachea, one with an inflammation trachea, and one with tracheal stenosis; they used FB only as a diagnostic tool for EF children's airway problems and not as a therapeutic tool.[16] A recent study reported that patients with congenital anterior glottis stenosis who underwent endoscopic balloon dilatation laryngoplasty could be successfully extubated within 72 h without complications.[21] In our study, all patients with EF exhibited a higher positive finding (93.3%) for upper airway problems, implying we could perform various FB techniques for upper airway problems in these patients. Moreover, our collective and significant findings were vocal cord granulations and subglottic stenosis in the REF group. This study had 20 children with vocal cord granulations or subglottic stenosis (or both). Following the diagnosis of vocal cord granulations or subglottic stenosis, nearly 45% (n = 9) of children received laser therapy by FB, and all were finally extubated and discharged from our hospital. Thus, FB is a useful tool for the early diagnosis of anatomical airway problems and devising the therapeutic plan.

In patients with REF, vocal cord dysfunction is not uncommon. A study demonstrated that bilateral vocal cord paralysis could cause airway obstruction and necessitate reintubation.[22,23] When indicated, tracheostomy is the gold standard therapy for patients with bilateral vocal cord paralysis because it permits time for spontaneous recovery.[17] In this study, of all patients with bilateral vocal cord palsy, three of the five (60%) required tracheostomy before discharge. These findings accord with the results of previous studies.

This study has some limitations. First, it was a retrospective clinical study, not a prospective trial; thus, all medical decisions were made by attending or FB examining clinicians, including the first performing FB with a trial of extubation and therapeutic interventions. As the age distribution in pediatric ICU is significant, having standard weaning and extubation protocol in all patients is challenging. Second, it was a single-center study with small sample size. Thus, further prospective, extensive studies with more participants and more standardized diagnostic, and therapeutic protocol are warranted for future clinical applications.

In conclusion, upper airway granulations or stenosis significantly augment the risk of REF in children; however, these could be diagnosed early by FB and guide the therapeutic protocol in acute cases. Thus, anatomical problems of upper airways should be considered in intubated children with EF, and FB is a useful tool for early diagnosis and management.

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References

1. Newth CJ, Venkataraman S, Willson DF, Meert KL, Harrison R, Dean JM, et al. Weaning and extubation readiness in pediatric patients. *Pediatr Crit Care Med* 2009;**10**:1−11.
2. Laham JL, Breheny PJ, Rush A. Do clinical parameters predict first planned extubation outcome in the pediatric intensive care unit? *J Intensive Care Med* 2015;**30**:89−96.
3. Kurachek SC, Newth CJ, Quasney MW, Rice T, Sachdeva RC, Patel NR, et al. Extubation failure in pediatric intensive care: a multiple-center study of risk factors and outcomes. *Crit Care Med* 2003;**31**:2657−64.
4. Epstein SK, Ciubotaru RL, Wong JB. Effect of failed extubation on the outcome of mechanical ventilation. *Chest* 1997;**112**:186−92.
5. Baisch SD, Wheeler WB, Kurachek SC, Cornfield DN. Extubation failure in pediatric intensive care incidence and outcomes. *Pediatr Crit Care Med* 2005;**6**:312−8.
6. Esteban A, Alía I, Gordo F, Fernández R, Solsona JF, Vallverdú I, et al. Extubation outcome after spontaneous breathing trials with T-Tube or pressure support ventilation. *Am J Respir Crit Care Med* 1997;**156**:459−65.
7. Farias JA, Retta A, Alia I, Olazarri F, Esteban A, Golubicki A, et al. A comparison of two methods to perform a breathing trial before extubation in pediatric intensive care patients. *Intensive Care Med* 2001;**27**:1649−54.
8. Boles JM, Bion J, Connors A, Herridge M, Marsh B, Melot C, et al. Weaning from mechanical ventilation. *Eur Respir J* 2007;**29**:1033−56.

9. Tapia-Rombo CA, De Leon-Gomez N, Ballesteros-Del-Olmo JC, Ruelas-Vargas C, Cuevas-Uriostegui ML, Castillo-Perez JJ. Predictors factors for the extubation failure in two or more times among preterm newborn. *Rev Invest Clin* 2010;**62**:412−23.
10. Khan N, Brown A, Venkataraman ST. Predictors of extubation success and failure in mechanically ventilated infants and children. *Crit Care Med* 1996;**24**:1568−79.
11. Baumeister BL, el-Khatib M, Smith PG, Blumer JL. Evaluation of predictors of weaning from mechanical ventilation in pediatric patients. *Pediatr Pulmonol* 1997;**24**:344−52.
12. Farias JA, Frutos F, Esteban A, Flores JC, Retta A, Baltodano A, et al. What is the daily practice of mechanical ventilation in pediatric intensive care units? A multicenter study. *Intensive Care Med* 2004;**30**:918−25.
13. Venkataraman ST, Khan N, Brown A. Validation of predictors of extubation success and failure in mechanically ventilated infants and children. *Crit Care Med* 2000;**28**:2991−6.
14. Soyer T. The role bronchoscopy in the diagnosis of airway disease in children. *J Thorac Dis* 2016;**8**:3420−6.
15. Peng YY, Soong WJ, Lee YS, Tsao PC, Yang CF, Jeng MJ. Flexible bronchoscopy as a valuable diagnostic and therapeutic tool in pediatric intensive care patients: a report on 5 years of experience. *Pediatr Pulmonol* 2011;**46**:1031−7.
16. Manna SS, Durward A, Moganasundram S, Tibby SM, Murdoch IA. Retrospective evaluation of a paediatric intensivist-led flexible bronchoscopy service. *Intensive Care Med* 2006;**32**:2026−33.
17. Kuo CH, Niu CK, Yu HR, Chung MY, Hwang CF, Hwang KP. Applications of flexible bronchoscopy in infants with congenital vocal cord paralysis: a 12-year experience. *Pediatr Neonatol* 2008;**49**:183−8.
18. Fontela PS, Piva JP, Garcia PC, Bered PL, Zilles K. Risk factors for extubation failure in mechanically ventilated pediatric patients. *Pediatr Crit Care Med* 2005;**6**:166−70.
19. Gaies M, Tabbutt S, Schwartz SM, Bird GL, Alten JA, Shekerdemian LS, et al. Clinical epidemiology of extubation failure in the pediatric cardiac ICU: a report from the pediatric cardiac critical care consortium. *Pediatr Crit Care Med* 2015;**16**:837−45.
20. Pereira KD, Smith SL, Henry M. Failed extubation in the neonatal intensive care unit. *Int J Pediatr Otorhinolaryngol* 2007;**71**:1763−6.
21. Yoo MJ, Roy S, Smith LP. Endoscopic management of congenital anterior glottic stenosis. *Int J Pediatr Otorhinolaryngol* 2015;**79**:2056−8.
22. Artime CA, Hagberg CA. Tracheal extubation. *Respir Care* 2014;**59**:991−1002.
23. Ellis PD, Pallister WK. Recurrent laryngeal nerve palsy and endotracheal intubation. *J Laryngol Otol* 1975;**89**:823−6.