The Safety of Aerodigestive Tract Flexible Endoscopy as an Outpatient Procedure in Young Children

Wan-Teh Chen[1,2], Wen-Jue Soong[1]*, Yu-Sheng Lee[1], Mei-Jy Jeng[1], Hua-Lun Chang[1], Betau Hwang[1]

[1]*Department of Pediatrics, Taipei Veterans General Hospital and National Yang-Ming University School of Medicine, and* [2]*Taiwan Adventist Hospital, Taipei, Taiwan, R.O.C.*

Background: Flexible endoscopy (FE) for the pediatric aerodigestive tract is an invasive and complicated procedure; therefore, it is usually performed under an inpatient setting. We investigated whether FE could be a safe procedure for outpatient young children (< 5 years old) and analyzed the findings.

Methods: Outpatient FE records were retrospectively reviewed between 1996 and 2003. Patients aged less than 5 years were enrolled and allocated to 3 age groups: group A (≤ 3 months), group B (4–12 months), and group C (1–5 years). Patients with or without previously known major airway anomalies were also grouped for analysis.

Results: A total of 728 children (479 boys, 249 girls) who underwent 834 FE procedures were collected. Of those without previously known airway anomalies, stridor was the most common symptom in group A (60.2%), and snoring in group B (34.1%) and group C (74.2%). Laryngomalacia was the most common FE finding in group A (60.2%) and group B (34.1%), and nasal adenoid hypertrophy in group C (69.6%). After FE, there were 57 admissions (6.8%), and higher in those aged less than 1 year or in those with major airway anomalies. Seven (0.7%) were complication-associated admissions.

Conclusion: From this study, we conclude that FE is a safe, effective and tolerable outpatient procedure in the majority of young children, and serious complications were uncommon. [*J Chin Med Assoc* 2008;71(3):128–134]

Key Words: fiberoptic bronchoscopy, outpatient procedure, young children

Introduction

Flexible endoscopy (FE) of the aerodigestive tract has already been recognized as an important diagnostic and interventional tool in pediatric clinical practice over the past 2 decades.[1–11] Sedation or general anesthesia are almost routinely used to improve patient comfort and cooperation as well as to reduce anxiety and stress for both the physician and the child.[12–17] The potential risks of major complications related to the FE procedure or anesthesia are low,[14–23] and less than 2% was reported in previous studies.[20,21] Despite advances in technology and capability with respect to pediatric FE, it is still regarded as an invasive and complicated procedure; therefore, most hospitals still arrange it out as an inpatient procedure.

The incidences of serious complications of FE in adult studies are as low as 2%, as shown by Hill et al.[19] Outpatient-based FE in selected adult cases has also been documented to be a safe procedure,[20–23] with an unexpected admission rate of 1.5%.[20] However, in pediatrics, studies have only focused on its clinical value.[1–11,24–32] Thus, the safety and efficacy of outpatient FE has remained largely unexamined, and related articles are limited.[33–38] This study reviewed our experience over the past 8 years with the outpatient FE procedure in infants and young children.

Methods

We retrospectively reviewed our medical records for FE examinations over a period of 8 years, from January 1996 to December 2003. Enrolled patients fitted the following 2 criteria: (1) they received an FE examination in an outpatient setting; and (2) they were less than

*Correspondence to: Dr Wen-Jue Soong, Department of Pediatrics, Taipei Veterans General Hospital, 201, Section 2, Shih-Pai Road, Taipei 112, Taiwan, R.O.C.
E-mail: wjsoong@vghtpe.gov.tw • Received: July 17, 2007 • Accepted: January 15, 2008

5 years old. Enrolled patients were then allocated into 3 groups by age: group A, ≤ 3 months old; group B, 4–12 months old; and group C, > 1 year old. In addition, patients with or without previously known, that is before this FE, major airway anomalies were grouped for analysis.

All FEs were performed by a team of skilled pediatric pulmonologists who were qualified for newborn and pediatric resuscitation and had each performed more than 2,000 FE procedures before involvement in this study in 1996 at Taipei Veterans General Hospital, a tertiary medical center in Taiwan. FE procedures were preceded by intravenous sedation in the pediatric bronchoscopy room, which was equipped with full vital sign monitors and resuscitation instruments. Various sizes of FEs with outside diameters of 2.2 mm (LF-P; Olympus, Tokyo, Japan), 3.0 mm (ENT-300PIII; Machida, Tokyo, Japan), 3.6 mm (ENF Type P4; Olympus), 4.0 mm (LF-2; Olympus) or 5.0 mm (FLT-SIII; Machida) were all used at some time. These FEs either had or did not have an inner channel.

Before FE, all children had a fasting period of at least 3 hours for elective FE, or the stomach contents were sucked out as completely as possible for emergency FE. Patients were premedicated with 0.02 mg/kg atropine (maximum, 0.4 mg), and the sedative agents midazolam (0.5–1.0 mg/kg, maximum 20 mg) and ketamine (0.5–2.0 mg/kg, maximum 70 mg) were also given, all intravenously. Doses were titrated to preserve the patient's spontaneous breathing if possible. Topical airway mucosa anesthesia with 2% lidocaine was applied by direct nasal instillation and transtracheal injection via the anterior neck into the tracheobronchial tree (total maximum, 7 mg/kg).

Heart rate and rhythm, respiratory rate, and oxyhemoglobin saturation by pulse oximetry were continuously monitored during and after the FE procedure, until the patient was fully awake and had returned to a stable cardiopulmonary status. Noninvasive blood pressure was measured every 5 minutes during the FE procedure and every 15 minutes after FE, until the patient was awake and stable. Pure and humidified oxygen (0.2–0.3 L/kg/min, maximum 3 L/min) was continuously delivered via a nasopharyngeal catheter (NPC) throughout the whole course of the procedure. The FE was always introduced via the nasal route into the pharynx, larynx, tracheal and bronchial lumen, as far as possible, for whole airway examination. After completion of the airway check, the FE was routinely switched into the esophagus and then stomach for upper digestive tract examination. At this time, a small oxygen flow (1–2 L/min), via the inner channel of FE or the original NPC, was gradually introduced into the esophagus (NPC alongside of the FE) to inflate the esophagogastric lumen for better viewing. Finally, the FE was introduced into bilateral ear canals to check those.

The findings from the FE procedure were analyzed, and the associated complications and outcomes were evaluated. Any immediate or delayed complications that occurred during the FE performance were reviewed from the medical charts or by telephone. Minor complications were defined as an event that did not affect or preclude completion of the procedure, such as epistaxis, transient episodes of desaturation or laryngospasm, or FE-related cough or post-FE fever. Major complications were defined as an event that significantly affected and caused the termination of the FE procedure or required aggressive intervention. These included seizure, oxygen desaturation (< 75%, or 10% below the baseline in already cyanotic patients), or bradycardia (< 60 beats/min) for more than 10 seconds, or a need for emergency endotracheal intubation. Such patients were routinely admitted after FE examination. The incidence of admission after the FE procedure was evaluated and the cause of the admission analyzed. Admission rates were compared between the different groups using the χ^2 test, and p values of 0.05 or less were considered significant.

Results

During the 8-year study period, a total of 728 patients (479 males, 249 females) were enrolled, and a total of 834 FE procedures were performed. The basic demographic data of the studied patients are shown in Table 1. There were 89 patients in group A, 113 patients in group B, and 545 patients in group C. Among the 683 patients who had no previously known airway anomalies, there were 83 (12.1%) cases in group A, 90 (13.2%) in group B and 510 (74.7%) in group C, and they underwent a total of 693 FE procedures. Some patients received FE on more than 1 occasion at different ages. In contrast, 45 patients had previously known major airway anomalies, and 141 FE procedures were performed on these patients because of related symptoms or as part of regular follow-up (Table 2). Among them, the distribution was 6 patients who underwent FE 7 times (5%) in group A, 23 patients who underwent FE 43 times (30.5%) in group B, and 35 patients who underwent FE 91 times (64.5%) in group C.

Table 3 shows the indications in patients without any previously known airway anomaly, all of whom underwent diagnostic FE. Among them, stridor was the most common indication for FE in group A (60.2%)

Table 1. Basic demographic data of patients who underwent outpatient flexible aerodigestive tract endoscopy*

Group	Normal airway†				Abnormal airway†				All patients			
	Case/FE	Sex, M/F	Admissions	Complications	Case/FE	Sex (M/F)	Admissions	Complications	Case/FE	Sex (M/F)	Admissions	Complications
A (≤ 3 mo)	83/83	54/29	7 (8.4)	2 (2.4)	6/7	4/2	3 (42.8)§	0 (0)	89/90	58/31	10 (11.1)¶	2 (2.2)
B (4–12 mo)	90/91	55/35	3 (3.3)	0 (0)	23/43	12/11	13 (30.2)§	1 (2.3)	113/134	66/47	17 (12.7)	1 (0.7)
C (> 12 mo)	510/519	343/167	12 (2.3)	0 (0)	35/91	22/13	19 (20.9)§	3 (3.3)	545/610	365/180	31 (5.1)	3 (0.5)
Total	683/693	452/231	22 (3.2)	2 (0.03)	45/141	27/18	35 (24.8)	4 (2.8)	728/834	479/249	58 (6.6)	6 (0.7)

*Data are presented as n or n (%); †patients without any previously known airway anomalies, of whom 5 received more than 1 FE at different ages; ‡patients with previously known airway anomalies, all of whom received more than 1 FE at different ages; §$p < 0.05$ compared with those without previously known airway anomalies; ¶$p < 0.05$ comparing groups A and B with C.

and snoring in both groups B (34.1%) and C (74.2%). Their FE findings (Table 4) showed that laryngomalacia was the most common lesion in group A (60.2%) and also group B (34.1%), while nasal adenoid hypertrophy was the most common in group C (69.6%). There were 27 FEs (3.9%, 27/693) with negative findings made up of 9 (10.8%) cases from group A, 9 (9.9%) from group B and 9 (1.7%) from group C. Therefore, in this study, the total positive finding rate for FE was 96.8% (807/834).

After FE, there were 57 admissions among 41 patients, which accounted for 6.8% of the total FE procedures. The admission rate was significantly higher ($p < 0.05$) in group A (11.1%) and group B (12.7%) than in group C (Table 5). In all 3 age groups, those with major airway anomalies also had a significantly higher ($p < 0.05$) admission rate than those without airway anomalies. Among all 57 admissions, 50 admissions were unrelated to the FE complications (Table 5), which accounted for 6% of all FEs. Among them, 44 admissions were for management of respiratory problems that had been found by this FE examination, and 6 admissions were already scheduled. There were fewer associations between the cause of admission and complications. There were 7 admissions due to FE-associated complications: 1 admission was due to the minor complication of fever and cough 3 days after FE, and 6 admissions (0.7% of all procedures) were due to major complications. Two admitted patients were young infants aged less than 3 months and without airway anomalies: 1 had a seizure attack during FE and the other suffered from apnea and cyanosis 2 hours after the completion of FE. Four complication-associated admissions occurred in 3 patients who all had previously known airway anomalies: 2 admissions were due to significant desaturation and bradycardia during balloon tracheoplasty in 1 patient with tracheal stenosis who had severe stent-associated granulation formation, and 2 admissions were due to impending cardiopulmonary failure in 2 patients with bronchial stenosis and stent implantation. All these 6 major complications were managed with initial resuscitation, endotracheal intubation and admission, and all of these patients were then successfully discharged home.

Discussion

FE is a low-risk and high-yield clinical tool that has already been documented in a number of studies.[1–8,15–17,23–32] Due to safety concerns, most FEs are performed as an inpatient procedure with pediatric patients.[1–8,15–17,23–32] Hawkins and Clark first reported

Table 2. Patients ($n = 45$) with previously known airway anomalies who underwent outpatient flexible endoscopy at different ages*

Airway problems	≤ 3 mo ($n = 6$) Case/FE	4–12 mo ($n = 23$) Case/FE	> 12 mo ($n = 35$) Case/FE
Choanal stenosis/atresia	1/1	2/2	1/8
Laryngomalacia with laser therapy	1/1	1/1	1/1
Vocal cord palsy with or without tracheostomy	2/2	4/6	4/8
Subglottic stenosis with or without stent	–	5/7	8/21
Tracheobronchial malacia/stenosis with stent implantation	1/1	8/19	13/40
Tracheobronchial malacia/stenosis with or without tracheostomy	1/2	3/8	6/9
Tracheostomy due to central nervous system anomaly	–	–	1/2
Esophageal stenosis	–	–	1/2

**Data are presented as n.*

Table 3. Indications* for outpatient flexible endoscopy in patients without previously known airway anomalies

Indications	≤ 3 mo ($n^{\dagger} = 83$) *n* (%)	4–12 mo ($n^{\dagger} = 91$) *n* (%)	> 12 mo ($n^{\dagger} = 519$) *n* (%)
Snoring	13 (15.7)	31 (34.1)	385 (74.2)
Stridor	50 (60.2)	24 (26.4)	64 (12.3)
Chronic cough	3 (3.6)	21 (23.1)	170 (32.8)
Noisy breathing sound	17 (20.5)	11 (12.1)	14 (2.7)
Dyspnea/tachypnea	17 (20.5)	16 (17.6)	56 (10.8)
Nasal congestion/discharge	1 (1.2)	6 (6.6)	85 (16.4)
Frequent chocking	7 (8.4)	8 (8.8)	6 (1.2)
Cyanosis	2 (2.4)	1 (1.1)	2 (0.4)
Feeding difficulty	2 (2.4)	–	7 (1.3)
Hoarseness	2 (2.4)	3 (3.3)	12 (2.3)
Persistent lung lesion by chest film	2 (2.4)	5 (5.5)	12 (2.3)
Frequent otitis media	1 (1.2)	1 (1.1)	18 (3.5)
BAL for tuberculosis	–	2 (2.2)	18 (3.5)
Atypical croup	–	1 (1.1)	–
Local wheezing/decreased breathing sound	–	1 (1.1)	4 (0.8)
Witness of foreign body aspiration	–	1 (1.1)	1 (0.2)

**More than 1 indication in some children; †at the age of this outpatient flexible endoscopy examination.*

the possibility of the outpatient FE procedure in pediatrics in 1987.[33] Although these outpatient FEs proved that the procedure could also be safely performed in pediatric clinics, most of these reports indicate that the examination was limited to an upper airway examination and was carried out with the patient awake and without sedation.[33–38] When evaluating the safety of the FE procedure, it must be determined if complications are the result of the procedure itself, sedation, or the patient's characteristics. Pediatric FE is often considered to be invasive, however, a large series of studies has reported that it is a tolerable procedure in most inpatients, including extreme premature infants, and the risks of major complications are low,[15–17] although 2 fatal cases were reported.[39,40] The incidence of minor complications such as epistaxis or low airway bleeding, cough, transient oxygen desaturation and laryngospasm, was found to vary across different studies, ranging between 5% and 10% to 23%,[13,15–17,41] and transient oxygen desaturation could be eliminated with oxygen supplement.[13,15–17] In this present study, we did not focus our investigation on these minor complications, which seem to be not uncommon and all reported examples were safely recovered from after appropriate management. There was only 1 case of admission after minor complications where there was a fever and cough 1 day after FE, and this admission was requested by the family.

Profound desaturation might progress to significant hypoxemia and may jeopardize the patient, placing him or her at great risk, and patients of young age or with significant central airway abnormalities are prone to develop profound desaturation,[15,41–43] and this was supported in our study. This severe desaturation may be

Table 4. Findings* from outpatient flexible endoscopy in children without previously known airway anomalies

Findings	≤ 3 mo ($n^{\dagger}$ = 83) *n* (%)	4–12 mo ($n^{\dagger}$ = 91) *n* (%)	> 12 mo ($n^{\dagger}$ = 519) *n* (%)
Upper airway			
Adenoid hypertrophy	1 (1.2)	16 (17.6)	361 (69.6)
Nasal tract narrowing	1 (1.2)	2 (2.2)	36 (6.9)
Rhinosinusitis	–	6 (6.6)	75 (14.5)
Nasal polyp	1 (1.2)	–	1 (0.2)
Foreign body in nasal tract	–	–	2 (0.4)
Pharyngomalacia	16 (19.3)	18 (19.8)	214 (41.2)
Tonsillar hypertrophy	–	1 (1.1)	59 (11.4)
Pharyngitis or mucosal swollen	3 (3.6)	10 (11)	74 (14.3)
Vallecular cyst	3 (3.6)	1 (1.1)	3 (0.6)
Laryngeal hemangioma	–	2 (2.2)	–
Laryngomalacia	50 (60.2)	31 (34.1)	82 (15.8)
Laryngeal edema	–	2 (2.2)	5 (1)
Laryngeal granuloma/web	1 (1.2)	–	3 (0.6)
Vocal cord palsy	11 (13.3)	5 (5.5)	6 (1.2)
Vocal cord web/granuloma	5 (6.0)	3 (3.3)	3 (0.6)
Vocal cord injury	–	–	5 (1)
Lower airway			
Tracheal stenosis	5 (6.0)	5 (5.5)	30 (5.8)
Tracheomalacia	3 (3.6)	7 (7.7)	15 (2.9)
Tracheobronchus	5 (6.0)	5 (5.5)	10 (1.9)
Tracheal granulation	–	–	5 (1)
Trifurcation of carina	3 (3.6)	3 (3.3)	13 (2.5)
Bronchomalacia	9 (10.8)	12 (13.2)	8 (1.5)
Bronchial stenosis	3 (3.6)	6 (6.6)	3 (0.6)
Bronchial granulation	–	2 (2.2)	7 (1.3)
Milk/foreign body aspiration	2 (2.4)	2 (2.2)	9 (1.7)
Bronchopulmonary inflammation	8 (9.6)	32 (35.2)	232 (44.7)
Esophagus			
Incompetent gastroesophageal sphincter	2 (2.4)	3 (3.3)	2 (0.4)
Esophagitis	–	–	2 (0.4)
Otitis media/external	2 (2.4)	8 (8.8)	134 (25.8)
Negative findings	9 (10.8)	9 (9.9)	9 (1.7)

**More than 1 finding in some children; †at the age of this outpatient flexible endoscopy examination.*

a multifactorial consequence of laryngospasm, bronchospasm, poor cardiopulmonary reserve, or excessive coughing, as well as respiratory depression due to sedation, and partial airway obstruction by the bronchoscope itself.[43] Major complications such as pneumothorax or significant desaturation have been demonstrated to be rare, and a rate of 1.7% was observed by de Blic et al.[15] Furthermore, Nussbaum experienced this phenomenon in only 21 of 2,836 (0.7%) children, and only 5 cases (0.18%) required endotracheal intubations.[16] No mortality occurred in either study.[15,16]

In this study, a positive finding, either mild or significant, in the aerodigestive tract after outpatient FE examination was high, at up to 96.8%, but the major complication rate was low. Patients with major FE-associated complications were routinely treated by admission for further appropriate management. Among the 57 admissions in our series, most were not related to complications. Patients who were aged less than 1 year or who had a major airway anomaly had a significantly higher admission rate. Major complications occurred in 2 patients (Table 5) aged less than 3 months (2/83, 2.2%) and 3 patients in the previously known airway anomalies group (3/141, 2.1%). This made up 0.7% of all FE procedures, and this result is compatible with that of Nussbaum,[16] despite the fact that different subjects were enrolled.

With regard to sedation or anesthesia, although its necessity for FE has not been established,[34–38,44–46] a number of studies have preferred to routinely give

Table 5. Causes of admission after outpatient aerodigestive tract flexible endoscopy (FE)

Cause of admission	Admissions, *n*
Scheduled admission	
For stent implantation	1
Change or removal of tracheostomy tube	5
Unscheduled admission, not related to FE complications	
Pneumonia or tracheobronchial inflammation	7
Evaluation of congenital heart disease or vascular ring	3
Surgery for vallecular cyst	1
Electrocauterization of tracheal granuloma	1
Laser therapy for laryngomalacia	1
Severe tracheobronchial malacia with intubation	1
Esophageal perforation due to tracheal stent	1
Adenoidectomy	1
Balloon dilatation for tracheobronchial stenosis or granulation	19
Removal of foreign body	9
Unscheduled admission, related to FE complications	
Minor complication (fever and stridor 1 day after FE)	1
Serious complication	
Convulsion	1
Cardiopulmonary compromise	5
Total	57

sedative drugs to reduce patient anxiety, fear and pain as well as for operator comfort. The potential risks associated with sedation or anesthesia were shown to be low in previous studies.[9–17] Most of the life-threatening adverse events were related to drug overdose, inadequate monitoring or inappropriate sedation.[18] The sedative drug dosages that we used were higher than those suggested in most available recommended regimens. However, there was no increase in the complication rate or the risk to young children, even when FE was performed on an outpatient basis. The American Academy of Pediatrics has documented the importance of the close monitoring and appropriate management of children during sedation.[47] Children can become very disoriented by unfamiliar surroundings and people, and this can be deemed a hostile environment. Inadequate sedation results in suboptimal scope information especially in young children due to excessive struggling or coughing, and the FE viewing can also be interfered with. Therefore, we highly recommend that even for outpatient FE, proper short-acting agents and appropriate management and monitoring should be routinely used to achieve a safe and satisfactory result.

Outpatient FE has generally been driven by a desire to cut costs, free up hospital beds, and reduce waiting times. In pediatric patients, it conveys almost the same obvious benefits as in adults. In this retrospective study, the related morbidity was low and the procedure was well tolerated by most young children, and this would substantially reduce medical costs as well as minimize the disruption to the child and their family.

In conclusion, pediatric FE is an increasingly important diagnostic and interventional tool for the aerodigestive tract. In our outpatient setting, especially for diagnostic FE, stridor was the most common indication in young infants and snoring in infants and children. Laryngomalacia was the most common finding in infants, and nasal adenoid hypertrophy in young children. The admissions associated with major FE complications were low, and the patients prone to this were aged less than 3 months or had a major airway anomaly. So, the FE procedure can be safely performed in selected young children on an outpatient basis under appropriate sedation and close monitoring.

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