Tokai J Exp Clin Med., Vol. 29, No. 1, pp. 1-5, 2004

Feasibility of Fiberoptic Bronchoscopy for Small Infants including Newborns

Takako NAKANO, Masahiro SHIKADA, Masahiro NOMURA, Fumiyo KUWAYAMA-KOMAKI, Eisuke SUGANUMA, Mayumi ISHIKAWA-KATO, Tadakazu SAKAI, Hitoshi HIRAKAWA*, Shigeru UENO*, Seishichi YOKOYAMA*, Fumio NIIMURA, and Yasumasa OH

Department of Pediatrics, Tokai University School of Medicine
**Department of Pediatric Surgery, Tokai University School of Medicine*

(Received December 18, 2003; Accepted February 2, 2004)

In pediatric practice, the application of fiberoptic bronchoscopy (FBS) has been limited to infants and children, primarily because the caliber of the available fiberscopes was too large for application to small babies including newborns. Recently, fiberscopes with thinner calibers were generated, prompting application of FBS to newborn patients. In the recent five years, we have utilized narrow-caliber FBS at the Neonatal Intensive Care Unit of the Tokai University Hospital. Through 21 FBS applications on newborn patients for various indications, we conclude that given careful monitoring of the patient's systemic conditions and management of ventilation, FBS can be safely applied on small babies including newborn patients and facilitate treatment of the airway problems.

Key words : NICU, bronchoscopy

INTRODUCTION

In recent years, fiberoptic bronchoscopy (FBS) has become a regular diagnostic modality in pediatric practice. For smaller babies including newborns, however, the caliber of the trachea is too small for a majority of fiberoptic bronchoscopes [1, 2]. Furthermore, primary diseases of newborns are often so severe and the general conditions are so poor that the potential risk of complications with FBS may be increased. As a result, the application of FBS for newborns has been limited to few medical institutions.

In the present report, we review the cases to which we have applied FBS at our Neonatal Intensive Care Unit (NICU) of the Tokai University Hospital and discuss the feasibility and clinical significance of FBS for sick babies at NICU.

PATIENTS AND METHODS

Patients

The present study includes 16 babies including newborns in whom we have utilized FBS at NICU of the Tokai University Hospital between April, 1998, and August, 2003. The number of FBS applications was 21 times in total, with multiple applications to some patients.

The age of the patients at the examination ranged from 3 to 257 days. The weight ranged from 1338 to 3716 g. Table 1 summarizes the primary diseases for which these babies were initially admitted to NICU. Esophageal atresia was most frequent, accounting for 7 cases, with other primary diseases including respiratory distress syndrome, multiple anomalies, congenital diaphragmatic hernia, Kasabach-Merritt syndrome, Down syndrome, Goldenhar syndrome, ventricular hemorrhage, and hy-

Takako NAKANO, Department of Pediatrics, Tokai University School of Medicine, Bohseidai, Isehara, Kanagawa 250-1193, Japan
TEL: 0463-93-1121 FAX: 0463-90-1611 E-mail: 0ammd007@is.icc.u-tokai.ac.jp

Table 1 Primary diseases of the patients

Primary disease	Number of cases
Esophageal atresia	7
Respiratory distress syndrome	2
Congenital diaphragmatic hernia	1
Down syndrome	1
Multiple anomalies	1
Hydrocephalus	1
Kasabach-Merritt syndrome	1
Cerebral hemorrhage	1
Goldenhar syndrome	1

Table 2 Indications for FBS

Indications	Number of cases*
Evaluation of the airway in esophageal atresia and diaphragmatic hernia	8*
Difficulty in extubation	4
Evaluation of tracheobronchomalacia	3
Inspiratory stridor	3*
Deterioration of respiratory insufficiency	2
Tachypnea	1
Pulmonary bleeding	1

*In one patient with esophageal atresia, FBS was indicated for both evaluation of the airway and inspiratory stridor.

drocephalus.

FBS was most often indicated for evaluation of the potential airway problems which may frequently coincide with esophageal atresia. Other indications were difficulty in extubation, evaluation of tracheobronchomalacia, inspiratory stridor, and deterioration of respiratory insufficiency, tachypnea, and pulmonary bleeding.

Methods

We used PF22 Fiberscope (2.2 mm caliber; Olympus, Tokyo) and performed FBS while the patient was in the incubator. In two cases with inspiratory stridor, patients were placed under general anesthesia, with the airway maintained by laryngeal mask with a caliber of 3.0 or 3.5 mm.

Upon FBS examination, two pediatric pulmonologists operated the bronchoscope, and one NICU staff physician consistently monitored the patient conditions for heart rate and respiration on pulse oximetry. A single examination by FBS was limited to 3 min regardless of the patient's favorable conditions. When deemed necessary, the examination was repeated up to 3 times after verifying the patient's conditions.

The findings were video recorded and evaluated by multiple physicians for definitive diagnosis.

RESULTS

FBS was performed 21 times on 16 patients including newborns, with multiple applications in 4 patients. The indications of the 21 FBS examinations are summarized in Table 2.

Evaluation of the airway in esophageal atresia and diaphragmatic hernia

The most frequent indication was evaluation of the airway in 7 patients with esophageal atresia, with which anatomical alteration of the airway is known to coincide [3], and one patient with congenital diaphragmatic hernia. Among these cases, FBS identified tracheobronchomalacia in 3 cases, abnormal bronchial branching in 2 cases, and intratra-

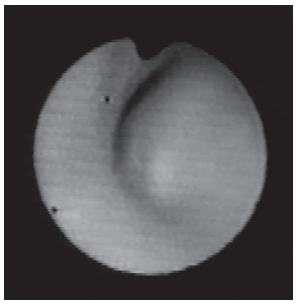

Fig. 1 A representative FBS image of tracheobronchomalacia.
An area of the trachea is narrowed due to tracheobronchomalacia.

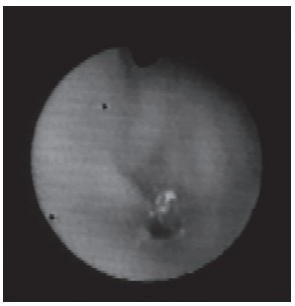

Fig. 2 A representative FBS image of subglottic stenosis.
A subglottic region with stenosis is presented.

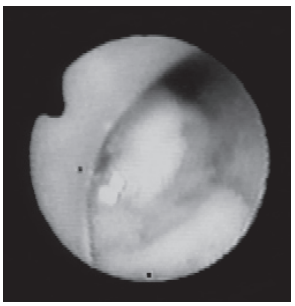

Fig. 3 A representative FBS image of tracheal granulation tissues.
An area of the trachea is presented. Granulation tissues appear as white materials.

cheal mucous plug in one case. In the remaining 2 cases, no abnormality was apparent in the trachea. One case was accompanied by both tracheobronchomalacia and abnormal bronchial branching. Figure 1 shows a representative FBS image of tracheobronchomalacia. The identified intratracheal mucous plug was removed immediately by tracheal suctioning. Tracheobronchomalacia was treated conservatively. For those with abnormal bronchial branching, subsequent care was formulated reflecting the presence of this abnormality.

Difficulty in extubation

Another frequent indication for FBS was difficulty in extubation, which occurred in 4 patients who had Down syndrome, congenital hydrocephalus, cerebral palsy after cerebral hemorrhage, and Goldenhar syndrome, respectively. In all 4 cases of difficulty in extubation, no abnormality was found in the trachea. Tracheostomy was done in 2 cases. In the case with Goldenhar syndrome, the endotracheal tube was successfully extubated after three months of intubation. In the case with congenital hydrocephalus, intubation was continued through the study period.

Evaluation of tracheobronchomalacia

Three patients with esophageal atresia were complicated with tracheobronchomalacia as revealed by the initial FBS examination, necessitating its follow-up evaluation by FBS. In the cases of tracheobronchomalacia, its severity was determined, and we treated the patients conservatively.

Inspiratory stridor

Inspiratory stridor, the next frequent indication for FBS, occurred in 3 patients with respiratory distress syndrome, multiple anomalies, and esophageal atresia, respectively. Upon FBS examination of these cases of inspiratory stridor, subglottic stenosis (Fig. 2) in a case with respiratory distress syndrome, and tracheobronchomalacia in a case with esophageal atresia were revealed. No tracheal abnormality was identified in a case with multiple anomalies. For the patient with subglottic stenosis, respiration was stablized by nasal oxygenation. Tracheobronchomalacia was treated conservatively by pharmacological approaches. In the case where no abnormality was identified, the patient was subjected to further analysis for the underlying cause of inspiratory stridor.

Deterioration of respiratory insufficiency

In a patient with respiratory distress syndrome, FBS examination of the airway was indicated on two separate occasions for deterioration of respiratory insufficiency. Each examination identified airway obstruction by mucous plug.

Tachypnea

A patient with cerebral palsy after cerebral hemorrhage developed tachypnea. FBS revealed granulation tissues in the trachea (Fig. 3), supposedly causing tachypnea in the baby. Upon localizing the granulation tissues, we determined an adequate length of the suction tube to avoid irritating the granulation tissue

Table 3 FBS findings

Findings	Number of cases
Tracheobronchomalacia	6
Tracheal mucous plug	3
Abnormal bronchial branching	2
Subglottic stenosis	1
Tracheal granulation tissue	1
Coagulated blood in the trachea	1
No abnormality in the trachea	7

during endotracheal suction.

Pulmonary bleeding

FBS was also indicated for pulmonary bleeding in a patient with Kasabach-Merritt syndrome. In this patient, coagulated blood was found accumulated in the trachea. We removed the coagulated blood by endotracheal suction, and changed the posture of the patient to allow spontaneous resolution of hemorrhagic lesions in the lung.

The findings of FBS described above are summarized in Table 3. Through the five years of FBS application at NICU, no complications were noted either during or after FBS.

DISCUSSION

The application of FBS in newborns and infants has been limited for various reasons. The most hindering was that the caliber of the previously available fiberscopes was too large for the trachea of newborns. Recent advent of fiberscopes with small calibers provided a minimally invasive means for bedside examination of the airway in newborns [4, 5].

In newborns, esophageal atresia and inspiratory stridor occur frequently, necessitating detailed examination of the airway for potential underlying disorders. In these clinical settings, FBS allows visual examination of the airway and, in combination with auscultation and imaging, provides thorough evaluation of the airway. Difficulty in extubation also arises often at NICU, and FBS allows immediate verification of the proper opening and location of the endotracheal tubes.

Our present review of the five-year experience of FBS application at the NICU of the Tokai University Hospital demonstrated that FBS is useful for the airway evaluation in esophageal atresia, difficulty in extubation, tracheobronchomalacia, and inspiratory stridor. We found that FBS is particularly effective in identifying the specific causes of inspiratory stridor. For those cases with abnormal bronchial branching, FBS helped us formulate a management protocol that takes into account the presence of this abnormality. When FBS was indicated in 4 cases of difficulty in extubation, the trachea was found essentially normal. Thus, after verifying the proper opening and location of the intratracheal tubes, we were able to direct the examination elsewhere promptly.

We found FBS essential for appropriate management of tracheobronchomalacia through 6 times of FBS performed on 3 cases with esophageal atresia complicated by tracheobronchomalacia. In small infants, visual examination of the airway and evaluation of tracheobronchomalacia by FBS is instrumental for formulating appropriate management. Similarly, effectiveness of FBS in managing tracheobronchomalacia has previously been described in pediatric liver transplant recipients [6].

In addition to its diagnostic use, FBS is also applicable to therapeutic purposes. Of the present 21 FBS examinations, airway obstruction by either secreted materials or local tissue mass was revealed in 5 cases. To remove these obstructing materials, we utilize PF22 fiberscope or, occasionally, MS-511 fiberscope from Medical Science (Tokyo, Japan). Thus, FBS helped us apply immediate therapy to airway obstruction.

As we have described, FBS is useful for visual evaluation and treatment of the airway problems in newborns. However, application

of FBS requires cautions. Because of the narrow trachea of the newborn, FBS can cause airway obstruction artificially. Appropriate means for adequate ventilation should be instituted. Since we use PF22 fiberscope with a caliber of 2.2 mm at our NICU, combined use of a caliber 2.5 mm intratracheal tube poses difficulty to maintenance of ventilation.

Maneuvering of the fiberscope also requires specific cautions. When airway stenosis is present, for example, particular care should be taken not to touch the mucous membrane with the fiberscope. Otherwise, edema develops in the airway mucous membrane postoperatively, aggravating the airway obstruction. Moreover, the narrow caliber of the trachea may limit examination of the area beyond the bronchi.

Monitoring of the patient's systemic conditions is also of critical importance. In particular, when the primary disease is severe and the systemic conditions of the patient are poor, heart rate and blood pressure can readily be altered during FBS. Complications such as hypoxia and bradycardia often associate with FBS [7]. Thus, monitoring of SpO2 and heart rate by pulseoximeter is an essential prerequisite of FBS.

In the present report, we demonstrated that given appropriate management of the patient's general conditions and maintenance of ventilation, FBS is a safe and effective means for the airway examination. Congenital disorders of the gastrointestinal tract or heart are often complicated with airway problems, requiring detailed examinations of the airway in newborns. Therefore, we advocate that FBS should be practiced actively at NICU.

ACKNOWLEDGMENTS

We would like to thank the staffs of the NICU of the Tokai University Hospital. We are also grateful to Dr. Fumio Niimura for critical reading and valuable comments on the manuscript and to Dr. Toshio Homma for editorial assistance.

REFERENCES

1) Wood RE, Postma D: Endoscopy of the airway in infants and children. J Pediatr 112: 1-6, 1988.
2) De Blic J, Scheinmann P: Fiberoptic bronchoscopy in infants. Arch Dis Child 67: 159-161, 1992.
3) Filler RM, Messineo A: Severe tracheomalacia associated with esophageal atresia: Results of surgical treatment. J Pediatr Surg 27: 1136-1141, 1992.
4) Hasegawa S, Inomata Y, Murakawa M, *et al.*: An ultrathin flexible bronchoscope with an external channel for bronchoscopy in intubated infants. J Bronchol 2: 290-292, 1995.
5) Hasegawa S, Tanaka K, Egawa H, *et al.*: Perioperative respiratory management with fiberoptic bronchoscopy in pediatric living-related liver transplantation. Surgery 119: 198-201, 1996.
6) Hasegawa S, Tanaka K, Inomata Y, *et al.*: Tracheobronchomalacia in pediatric liver transplant recipients. J Bronchol 5: 298-301, 1998.
7) Hasegawa S, Wada H, and Hitomi S: I. Endoscopic approach to pulmonary diseases. 2. Bronchoscopy for critical respiratory care in neonates, infants, and children. Kekkaku 75: 47-50, 2000. (in Japanese)