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Assessment in Pediatric Thoracic Surgery
—An Institutional Report—

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Abstract：Background：Thoracotomies are rarely performed in children. We reviewed and examined a series of child patients who underwent a thoracotomy at our hospital. Methods：A thoracotomy approach was attempted in 28 patients from 1994 to 2004. The patients were separated into the following four groups：lung tumor (LT), mediastinal tumor (MT), congenital disease (CD), and immune disease (ID). Differences between the groups were determined using the two-tailed paired Student's t-test, with values of $p<0.1$ considered to have tendency toward clinical significance. Results：Postoperative morbidity occurred in only two cases (5.8%), and consisted of atelectasis in one case and chylothorax in the other. There was no perioperative mortality. Three of our patients died during the follow-up, with two dying of malignancy and one of post-pneumonectomy syndrome. The five-year survival rate among our cases of metastatic lung tumor was 66.6%. The assessment of blood loss was slightly higher in the CD ($p=0.07$) and MT ($p=0.075$) groups than in the LT group. In addition the difference between CD and the other groups in terms of the mean age tended to be lower, especially in comparison to the LT ($p=0.059$). Conclusions：Candidates for a thoracotomy for child patients should be screened carefully according to their congenital background and other factors.

Key words：Pediatric thoracotomy, Assessment, Lung and mediastinal disease

Introduction

A thoracotomy is much more frequently performed in adults than in children. However, there has been a relative increase in such surgical cases in recent decades because of advances in pre- or postoperative care, which have decreased the risk of the procedure in children.[1)–2)] Furthermore, a open-lung biopsy at the optimal timing can help make a diagnosis or can be guide for accurate therapy in children.[3)] Recently, less invasive techniques such as video-assisted thoracotomy (VATS) have been developed and used as alternatives to conventional thoracotomy in many cases.[4)] Some new reports have reported that VATS is effective and safe for the treatment of children.[5)] The advanced technique of one-lung ventilation, which allows for a good view and adequate resection, are considered to make it easier to give an appropriate operation in children.[6)] Now it's time to be more aggressive in child thoracotomy concerning therapy or diagnosis. The aim of this study was to retrospectively analyze our 10-year experience of performing a thoracotomy in children at our institution, in order to investigate the influence of surgical invasiveness on morbidity and outcome.

Subjects and Method

From May 1994 to December 2004, 1800 patients underwent a pulmonary surgical resection at Fu-

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kuoka University Hospital. Of these patients, we retrospectively selected 28 children for whom the primary approach was a thoracotomy. Neonatal and infant cases were excluded in this study, since a thoracotomy for these patients is generally performed by a pediatric surgeon, and the patients' backgrounds conditions tend to vary widely. In the present series, all procedures were performed by a thoracic surgeon. The patients received general anesthesia and 16 were given single-lung ventilation (SLV) with endobroncheal blocker. Our inclusion criteria for VATS were as follows : well-isolated intralobar fissure, nearly free from adhesion in the thoracic cavity, and the ability to perform SLV and using thoracoscopic (5-mm in diameter) instruments.

The patients were separated into the following four groups according to their disease : a lung tumor (LT) group, a mediastinal tumor (MT) group, a congenital disease (CD) group, and an immune disease (ID) group.

Operative assessments :

In the case of each patient, the presence of the following was recorded : blood loss at surgery, the duration of the surgical time, the duration of chest tube intubation, the duration of post-surgical hospital stay, prolonged air leak, pneumonia, and atelectasis confirmed by a chest roentgenogram.

Statistical analysis :

All statistical analyses were performed with the StatView 5.0.1 software package (SAS Institute Inc., Cary, NC). Differences between the groups were determined using the two-tailed paired Student's t-test, with values of $p<0.1$ considered to have a tendency toward clinical significance.

Results

Patient population :

A summary of the 28 patients is shown in Table 1. There were 13 males and 15 females in this study, and the average age was 9.52 ± 4.28 years. Among the 15 patients in the neoplastic group, there were 9 patients with lung tumors (LT), including both metastatic or benign tumors, and 6 patients with mediastinal tumors (MT). Among the 13 patients in the non-neoplastic group, there were 8 with congenital disease (CD), 5 with immune deficiency (ID). In the lung procedures, there were 6 lobectomies, 1 segmentectomy, 1 pneumonectomy, 1 bronchiectomy, 8 wedge resections, and 1 giant bullectomy. In the mediastinal procedures, there were 2 extended thymectomies for myasthenia gravis (MG), and 6 tumor extirpations. These procedures are summarized in Table 2. Of these procedures, 7 were undergone with the technique of video-assisted thoracic surgery (VATS) ; these consisted of 1 case of a lobectomy for sequestration, 1 with extended thymectomy for MG, and 5 wedge resections for lung tumor or good pasture disease. All VATS cases displayed uneventful postoperative courses.

Variation of respective factors and subgroup :

An analysis of the operative data showed the following. The mean age was 7.5 ± 3.29 in the CD

Table 1. Profiles of the children who underwent a thoracotomy

Neoplasm		Non-neoplasm	
Lung tumor (LT)	(9)	Congenital disease (CD)	(8)
Metastatic lung tumor	6	Congenital pulmonary cyst	3
Osteozarcoma	5	Sequestration	3
Wilms	1	Juvenile emphysema (Marfan)	1
Benign lung tumor	3	Bronchoectasia (E-B fistel)	1
Bronchial tumor	1		
Inflammatory pseudotumor	2		
Mediastinal tumor (MT)	(6)	Immune deficiency (ID)	(5)
Neurogenic tumor	4	Miasthenia gravis	2
Bronchial cyst	1	Good pasture's syndrome	1
Teratoid tumor	1	Idiopathic chylothorax	1
		Histiocytosis	1

group and 11.09±4.15 in the LT group. The CD group tended to be younger (p=0.059) (Fig. 1a). Blood loss (ml/kg) was 0.89±1.13 in the LT, 3.52±3.63 in the MT, 4.67±5.31 in the CD, and 1.23±1.23 in the ID group. Blood loss in the LT group was slightly fewer than that in the CD (p=0.07) or MT (p=0.075) groups (Fig. 1b). The operative time (minutes) was 170.45±100.48 in the LT, 169.8±83.23 in the MT, 256.2±116.57 in the CD, and 232.5±94.82 in the ID group (Fig. 1c), and showed no statistical differences. In terms of the duration of chest tube intubation, although the CD group had a somewhat longer duration, there were no significant differences among the subgroups (Fig. 1d). The duration of post-operative hospital stay was not significantly different among the groups.

Table 2. Surgical procedures

Lung		18
	Wedge	(8)
	Segmentectomy	(1)
	Lobectomy	(6)
	Pneumonectomy	(1)
	Bronchiectomy+plasty	(1)
	Giant bullectomy	(1)
Mediastinum		8
	Extended thymectomy	(2)
	Tumor extirpation	(6)
Pleural and others		3
	Decortication	(1)
	Ligation of the thoracic duct	(1)
	Cartilageresection	(1)

Assessment of postoperative morbidity :

Postoperative early morbidity occurred in two

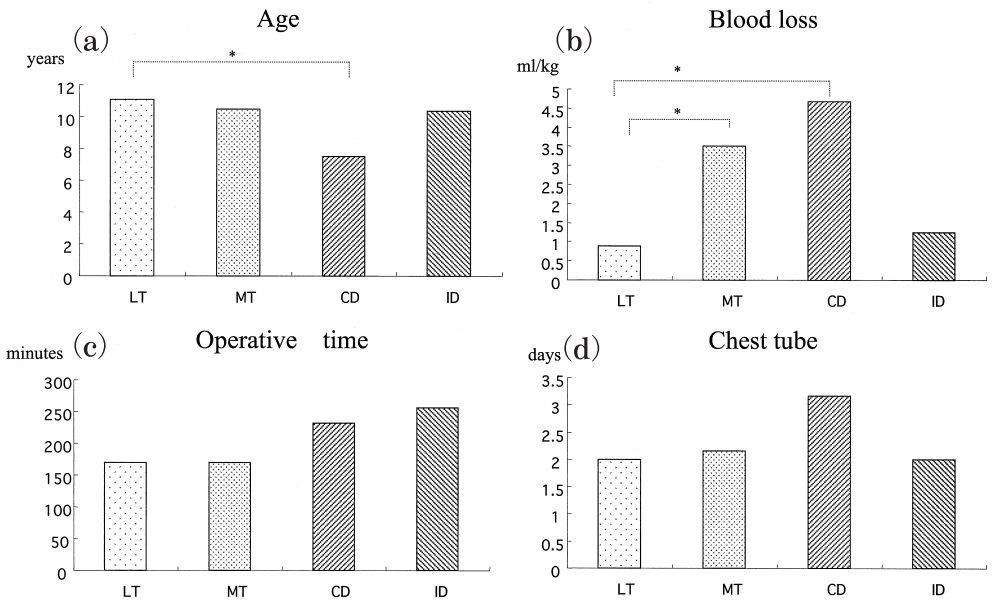

Fig. 1. Assessment of the safety and efficacy of a thoracotomy by group. LT : Lung tumor, MT : Mediastinal tumor, CD : Congenital disease, ID : Immunodeficiency disease. (a) Mean age (b) Blood loss at surgery (c) Duration of surgery (d) Duration of chest tube intubation. *p<0.1

Table 3. Morbidity and mortality.

Patients	Disease	Cause	Months
(Mortality)			
15y F	Osteosarcoma	Multiple recurrence	9
9y F	Osteosarcoma	Multiple recurrence	35
5y F	E-B fistula	Respiratory failure*	76
(Morbidity)			
7y M	Sequestration	Chylothorax	
8y F	Congenital pulm. cyst	Atelectasis	

*post pneumonectomy syndrome
E-B fistula : Esophageal-bronchial fistula

cases ; one of these patients (2.9%) developed atelectasis following a lobectomy for congenital pulmonary cyst and the other (2.9%) developed chylothorax following a lobotomy for pulmonary sequestration (Table 3). The total postoperative complication rate was thus 5.8%. There was no perioperative mortality. But a total of three children died during the follow-up period. Two of these children had recurrence of osteosarcoma despite undergoing a second operation. The other 4 cases of the oncologic group (metastatic lung tumor group) are still alive. The third child, a girl with a right pneumonectomy and esophageal-bronchial fistula, developed severe scoliosis and post-pneumonectomy syndrome in the 6-year postoperative period.

Discussion

Despite the continued increase in the number of adult patients undergoing thoracic surgery, children and young adults rarely undergo this operation. These populations have specific characteristics and necessitate different peri-operative care. A high percentage (75%) of our patients underwent either a lobectomy or a pneumonectomy in this congenital group. Recently, Shanmugam et al. reported that patients with congenital lung malformations should be evaluated for malignant degeneration makes resection impressive, even in asymptomatic cases. In addition, similar to our present series, a lobectomy was an important option in Shanmugam's 31 patients.[7] One of our patients experienced delayed post-pneumonectomy complications. This case showed a marked herniation of the remaining left lung with a mediastinal shift to the right side on follow-up, which finally caused compression of the left bronchus between the aorta and vertebra. Although we implanted silicone and expandable stents in an attempt to dilate the bronchus, she developed severe pneumonia which eventually led to death. Lezama-del Valle reported on the long-term complications of scoliosis after a pneumonectomy.[8] Children who undergo pneumonectomy before the age of 10 years may develop scoliosis in the long-term.[9] Our patient who underwent a pneumonectomy was 5 years old at the time of surgery, and died at 10 years of age. Some different kind of treatment may thus be required in young children with possibility of overgrowth to the opposite thoracic side after pneumonectomy. None of our 6 cases who underwent a lobectomy developed scoliosis. In general, most pediatric thoracic malignancy consists of pulmonary metastases from primary solid tumors. Among these patients, osteosarcoma is the most common disease. It is not clear whether the surgical criteria for pulmonary metastasis in children are comparable with those in adults. Torre et al. showed that the 5-year survival rate was 53.8% for his 44 cases (31 patients with osteosarcoma, 8 with Ewing's sarcoma, 3 with Wilms, and 2 with testicular cancer).[10] Two of our cases (5 osteosarcoma and one Wilms) died of recurrence, in which the survival rate was similar. Torre's data showed that children and young adults after a pulmonary metastasectomy with a disease free interval (DFI) of more than 10 months had better survival than those with a DFI of less than 10 months. A thoracotomy should thus be considered in children presenting with pulmonary metastases with long DFI.

The limiting factor in one previously reported lung ventilation was the ability of the child's airway to accommodate the bronchoscope. Masters et al. reported on the developmental progress of pediatric bronchoscopy.[11] As a result of such progress, VATS can be performed safely and easily, even in children, using the new bronchoscope.

Seven of our cases were treated with the VATS approach. These cases received a lobectomy for sequestration for pulmonary sequestration (n=1), extended thymectomy for MG (n=1), a wedge resection for a diagnosis of good pasture disease (n=1), and various treatments for a resection of metastatic tumors (n=5). None of the patients herein described required conversion to a standard thoracotomy. However, in one patient who suffered from chylothorax, the chest tube was not removed until day 7. The morbidity rate of VATS in children of the present series was 12.5%. Other children with VATS made a good recovery ; in this patient, the chest tubes were left for 1.1 days and the post-hospital stay was 3.6 days on average. Another study presented the data of 88 children who received a wedge resection by VATS, and in

this group the average hospital stay was 1.1 days.[12] We divided our patients into four sub-groups in this study. The purpose of this division was to clarify the operative and post-operative invasiveness of children undergoing a thoracotomy. The comparison of the peri-operative data revealed some differences among the groups, as shown Fig. 1 ; blood loss at surgery tended to be higher in the CD group than in the LT group (P=0.07). We calculated the value of blood loss (ml/kg) according to the individual child body, because who had wide variety of age and weight which affected the level of invasiveness. The duration of surgery did not differ substantially among the groups. There were also no significant differences in the various parameters of post-operative care, such as the duration of chest tube intubation. Cases of CD showed a somewhat longer chest tube intubation, but the difference did not reach the level of statistical significance. The surgery stress for the patients with CD, which tended to be younger, were thought to be greater in comparison to the other groups who underwent a thoracotomy. This may indicate the possibility that, as far as CD is concerned, both the operative and postoperative care is important. Child thoracic disease tends to include rare diseases in comparison to adult disease. Similar cases were seen in our patients, including idiopathic chylothorax, good pasture syndrome, histiocytosis, and bronchial neulemmoma. Prabhakaran et al. reported a case who successfully underwent bronchoplasty in a very small baby (779 g at birth) and precise attention to technical detail and meticulous postoperative care contributed to the long-term benefit for pulmonary conservation.[13] In contrast to his report concerning age, we experienced the case of a 15-year-old boy who underwent a bronchiectomy with plasty. These reports may indicate that bronchoplasty procedures have obvious advantages in children because of their long life expectancy despite the difficulties due to a small luminal diameter. A child thoracotomy thus tends to show a great deal of variety between the cases and there is only a small number of such cases in comparison to adults. Because of these backgrounds, the surgical criteria and postoperative care of children must be clearly established and then be carefully carried out.

However, our series showed a thoracotomy to be a feasible, safe, and effective procedure in children.

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