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Thoracoscopic Surgery in Children

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Abstract

Purpose: A minimally invasive thoracoscopic surgery offers several options in diagnosis and surgical treatment in the field of pediatric surgery. We would like to review our surgical experience and to assess the clinical outcomes and problems encountered during thoracoscopic surgery in children and adolescents focusing on children less than 6 years old.

Patients and Methods: In 1992 and 2003, 977 patients underwent thoracoscopic surgery for chest diseases. Among them, from 1994 to 2003, 71 children and adolescents underwent thoracoscopic surgery. The thoracoscopic surgical procedures were classified into thoracoscopic surgery (TS) and video-assisted thoracic surgery (VATS). TS was performed through three or four trocar ports. VATS was performed through a small chest incision (minithoracotomy) with one or two trocar ports.

Results: There was no morbidity or mortality associated with the thoracoscopic surgical procedures. None of the patients required a conversion to standard thoracotomy. The thoracoscopic surgical procedures were feasible in 71 children and adolescents with chest diseases including spontaneous pneumothorax, pulmonary nodules, diffuse pulmonary disease, pulmonary sequestration, and mediastinal tumors, and in those with palmar hyperhidrosis. TS was performed on two of five children with benign diseases including diffuse pulmonary disease and mediastinal bronchogenic cyst. VATS was performed on three children with pulmonary sequestration, lymphoid interstitial pneumonia and mediastinal Ewing's sarcoma. In one child with lymphoid interstitial pneumonia, the thoracoscopic surgery was converted to VATS because adhesion did not allow TS. The TS allowed rapid histological diagnosis and surgical treatment for benign pulmonary diseases and mediastinal cyst. Patients who were suffering from disease-related symptoms obtained complete relief with an uneventful postoperative course and quickly returned to their normal life. A boy who underwent lobectomy showed a normal growth rate for 4 years postoperatively. In the case of malignant chest diseases, the combination of chemotherapy and VATS was an effective treatment strategy.

Conclusions: We considered that the thoracoscopic approach is a rapid and simple method in the therapeutic diagnosis and surgical treatment of children and adolescents, even in children less than 6 years old. Cosmetic benefits were also obtained for girls. However, the

most important consideration is the decision on a treatment strategy made by both pediatrician and thoracic surgeon.

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Key words: children, infant, chest disease, video-assisted thoracic surgery, thoracoscopic surgery

Introduction

Since the thoracoscopic surgical approach in children and adolescents was first introduced by Rodgers et al.¹ in 1979, thoracoscopy as a minimally invasive surgery has been widely accepted as a strategy for establishing quick diagnosis and treatment due to its feasibility and safety²⁻⁷. Lung excision was employed for histopathological diagnosis and the decision on treatment strategy, because diffuse pulmonary diseases such as interstitial pneumonia require histopathological diagnosis. Lobectomy by video-assisted thoracic surgery (VATS) has also been reported for pulmonary diseases including malignancy⁸⁻¹⁰. Thoracoscopy has been utilized to diagnose and excise a mediastinal tumor, which affects the quality of life^{11,12}. Regarding malignant diseases, several authors have reported that the thoracoscopic surgery enables a rapid recovery from surgical intervention and the immediate initiation of a

scheduled chemoradiotherapy compared with conventional thoracotomy^{3,4,6,13,14}. Among these reports, the percentage of children less than 6 years old among the patients treated was approximately 10%¹³. Therefore, we reviewed our surgical experience and problems encountered during thoracoscopic surgical procedures focusing on children less than 6 years old.

Patients and Methods

Between 1992 and 2003, 977 patients underwent thoracoscopic surgical procedures including thoracoscopic surgery (TS) or VATS for chest diseases at Nippon Medical School hospital. The patients comprised 71 children and adolescents (7.2%) with a mean age of 15 years (**Table 1**) including five children (7.0%) less than 6 years old with a mean age of 2 years and 8 months (**Table 2**).

Surgical technique: TS was carried out using a rigid 5-mm-diameter thoracoscopy (30 degrees, Olympus corp., Lake Success, N.Y.) through three or four

Table 1 Indications for thoracoscopic surgery and VATS in children and adolescents

Lung (n = 43)	Number	Procedures	Approaches
Diffuse pulmonary disease	2	Excision	TS, VATS
Intrapulmonary bronchogenic cyst	1	Excision	TS
Pneumothrax	42	Excision	TS
Pulmonary sequestration	1	Lobectomy	VATS
Mediastinum (n = 28)			
Pericardial cyst	1	Excision	TS
Lipoma	2	Excision	TS
Teratoma	1	Excision	TS
Bronchogenic cyst	2	Excision	TS
Palmar hyperhidrosis	21	Sympathectomy	TS
Ewing's sarcoma	1	Excision	VATS

Seventy-one children and adolescents underwent 74 thoracoscopic surgical procedures including three patients who underwent thoracoscopic surgery for pneumothorax of the contralateral lung. TS, thoracoscopic surgery; VATS, video-assisted thoracic surgery.

Table 2 Children less than 6 years old who underwent thoracoscopic surgery or VATS

Patient	Gender	Age	Diagnosis	Approach	Surgical procedures	DOS (min)	BL (ml)	P/O stay
1	Boy	2 yr 4 mo	Pulmonary hemosiderosis	TS	Lung excision	73	minimal	2 days
2	Girl	1 yr 4 mo	Lymphoid interstitial pneumonia	VATS	Lung excision	68	minimal	4 days
4	Girl	5 yr 10 mo	Mediastinal bronchogenic cyst	TS	Total excision of cyst	175	minimal	9 days
3	Boy	1 yr 6 mo	Pulmonary sequestration	VATS	Left lower lobectomy	255	150	8 days
5	Girl	3 yr 2 mo	Mediastinal Ewing's sarcoma	VATS	Total excision of tumor	250	113	4 days

TS, thoracoscopic surgery; VATS, video-assisted thoracic surgery; DOS, duration of surgery; BL, blood loss; P/O stay, duration of postoperative hospital stay; yr, year; mo, month.

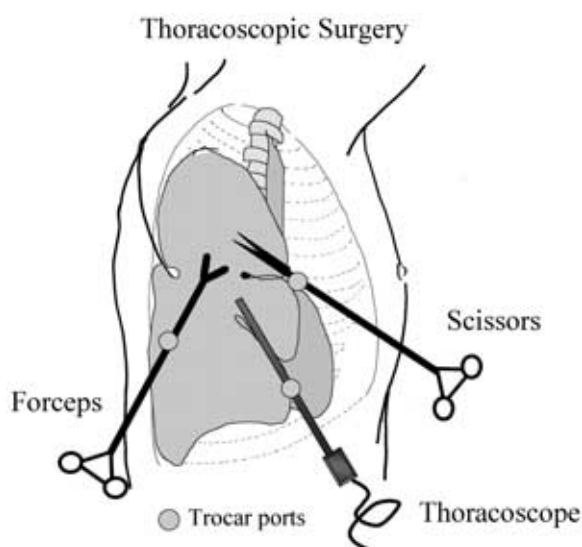


Fig. 1 Technique of thoracoscopic surgery using three trocar ports

trocar ports (1.0-cm-long skin incision) for lung biopsy and benign mediastinal tumor (**Fig. 1**). VATS was carried out through a 3-cm-long chest incision (minithoracotomy) with two additional trocar ports supported by thoracoscopic observation. In VATS, minithoracotomy was performed for the safe dissection and division of vessels and the removal of a large specimen from the thorax. Selective one-lung ventilation was used in some older children and adolescents to allow ipsilateral lung collapse. In some children, an endotracheal tube was inserted into the contralateral main bronchus to achieve ipsilateral lung collapse. Using endoscopic instruments, surgical procedures were carried out similarly to those of conventional thoracotomy. After resection, the specimen was removed through one of the trocar

ports using a plastic retrieval bag.

Results

Seventy-one children and adolescents underwent 74 thoracoscopic procedures (**Table 1**), comprising 41 boys and 25 girls with a mean age of 15 years (range, 1 to 19 years). The procedures included diagnostic lung biopsy, excision and pleurodesis for pneumothorax, excision of pulmonary nodules, pulmonary lobectomy, excision of mediastinal tumors, and sympathectomy for palmar hyperhidrosis as therapeutic strategies. The average duration of thoracostomy tube drainage was 1.1 days (0~7 days), and the average duration of postoperative hospitalization was 2.5 days (1~11 days). There was no morbidity or mortality associated with the thoracoscopic procedures and none of the children required a conversion to conventional thoracotomy.

Of the 71 children, two children underwent VATS and three children, thoracoscopic surgery. These five children comprised two boys and three girls with a mean age of 2 years and 8 months (range, 1 year and 6 months to 5 years and 10 months) (**Table 2**).

Patient 1 was a boy aged 2 years and 4 months showing decreased activity in daily life. Chest radiography and chest computed tomography (CT) revealed a miliary shadow, and the patient was referred to the Division of Thoracic Surgery for lung biopsy. Thoracoscopic observation revealed multiple bluish spots on the surface of the lungs. A lung

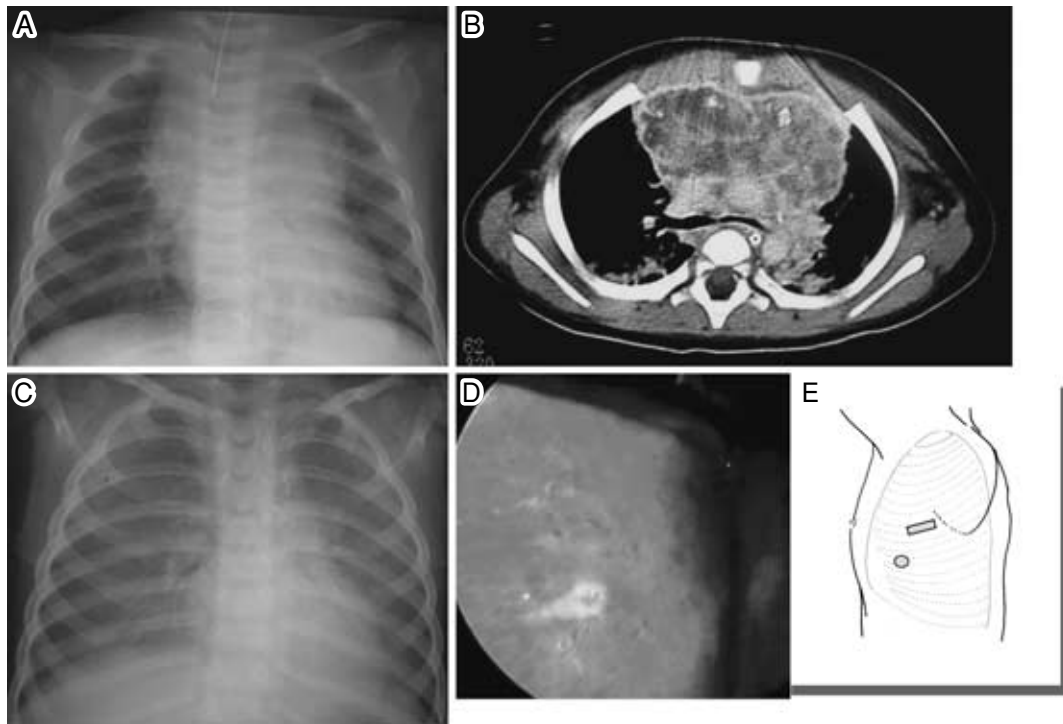


Fig. 2 Patient 2. Lung biopsy for lymphoid interstitial pneumonia after chemotherapy **A**, chest radiography before chemotherapy for mediastinal Langerhans' cell histiocytosis; **B**, chest CT before chemotherapy; **C**, chest radiography showing diffuse reticular shadow 9 months after chemotherapy; **D**, thoracoscopic view of the left lung; **E**, position of minithoracotomy and a trocar port.

biopsy of the lower lobe was carried out by TS, which failed due to adhesion; therefore TS was converted to VATS with one trocar port. The histopathological diagnosis was pulmonary hemosiderosis.

Patient 2 (**Fig. 2**) was a girl aged 1 year and 4 months. She was brought to the Department of Pediatrics having suffered from presenting with progressive dyspnea since she was 6 months old. Chest radiography (**Fig. 2A**) and chest CT (**Fig. 2B**) revealed a huge mass in the anterior mediastinum pressing the trachea. Immediately the patient was managed under a respirator, and a partial tumor resection was carried out to reduce tumor volume, and biopsy was conducted by median sternotomy. A histopathological examination revealed the tumor as Langerhans cell histiocytosis. She had a complete remission by chemotherapy after the tumor reduction surgery, and she returned to a normal life. However, she suffered from progressive exertion dyspnea 9 months after the chemotherapy. Chest radiography (**Fig. 2C**) and chest CT revealed diffuse interstitial shadows on both lower lung fields. Lung

biopsy was carried out by VATS (**Fig. 2D**) and revealed the presence of lymphoid proliferative pneumonia (lymphoid interstitial pneumonia pattern). The duration of the surgery was 68 minutes and blood loss was minimal. The patient recovered and was discharged after the administration of steroid therapy.

Patient 3 (**Fig. 3**): A girl aged 5 years and 10 months was referred to the Nippon Medical School Hospital, because she had been suffering from persistent cough and low-grade fever for the last two years. These symptoms persisted even after antibiotic administration. Chest radiography (**Fig. 3A**) and chest CT revealed a spindle-shaped mass near the left upper mediastinum adjacent to the thoracic vertebra. Magnetic resonance imaging (MRI) (**Fig. 3B**) showed a T2-weighted image indicative of a cystic lesion. Thoracoscopic observation revealed a huge 10×6 cm cyst in the posterior mediastinum. Because the cyst was very large, fine-needle aspiration was performed through a trocar port to reduce cyst volume (**Figs. 3C and D**). The cyst contained a yellowish clear fluid. The

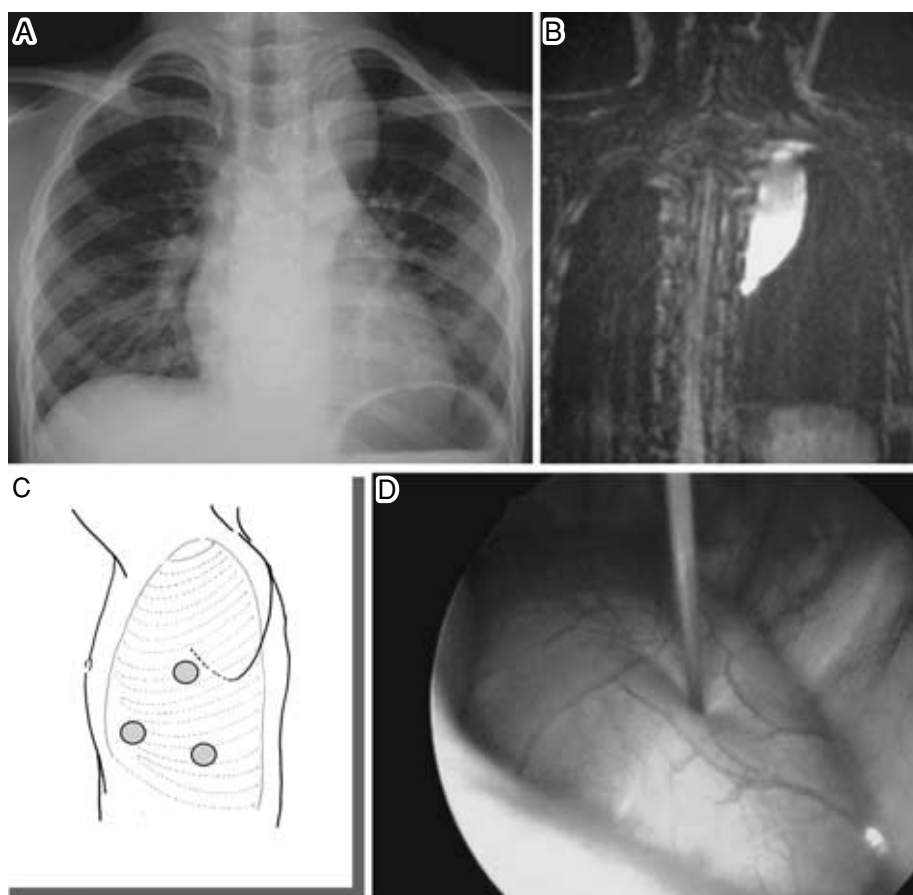


Fig. 3 Patient 3. Mediastinal bronchogenic cyst

A, preoperative chest radiography; **B**, preoperative MRI; **C**, site of trocar ports; **D**, cystic content was aspirated by fine needle aspiration to decrease cyst.

cyst was removed by TS through three trocar ports, in an uneventful procedure. The duration of the surgery was 175 minutes and blood loss was minimal. She was diagnosed as having a bronchogenic cyst. The symptoms of the patient disappeared and she was pleased with the cosmetic benefit afforded by the surgery.

Patient 4 (**Fig. 4**): A boy aged 1 year and 6 months was suffering from recurrent pneumonia. Close examination was carried out at the Department of Pediatrics, which revealed the pulmonary sequestration of the left lower lobe. Chest radiography (**Fig. 4A**) revealed a round shadow in the left lower lobe and aortography revealed the presence of an aberrant artery from the abdominal aorta (**Fig. 4B**). The patient underwent left lower lobectomy by VATS. A 4-cm-long minithoracotomy was made in the fifth intercostal space near the posterior axillary line (**Fig. 4C**). Sequestered lung

tissue (**Fig. 4D**) was detected in the posterolateral basal segment of the left lower lobe. The aberrant artery (4 mm in diameter and 1 cm in length) existed around the posterior mediastinum and entered the sequestered lung tissue. The aberrant artery was ligated and divided. The duration of the surgery was 255 minutes and blood loss was 150 ml. The postoperative course was uneventful. The patient was completely cured of the symptoms and showed a normal growth rate for 4 years postoperatively (**Fig. 5**).

Patient 5 (**Fig. 6**): A girl aged 3 years and 2 months was brought to the Department of Pediatrics presenting with progressive paraplegia of the lower limbs. A round shadow in the posterior mediastinum was detected by chest radiography (**Fig. 6A**). Chest CT (**Fig. 6B**) and MRI revealed the presence of a mediastinal solid tumor encroaching into the spinal canal pressing the spinal cord. A CT-

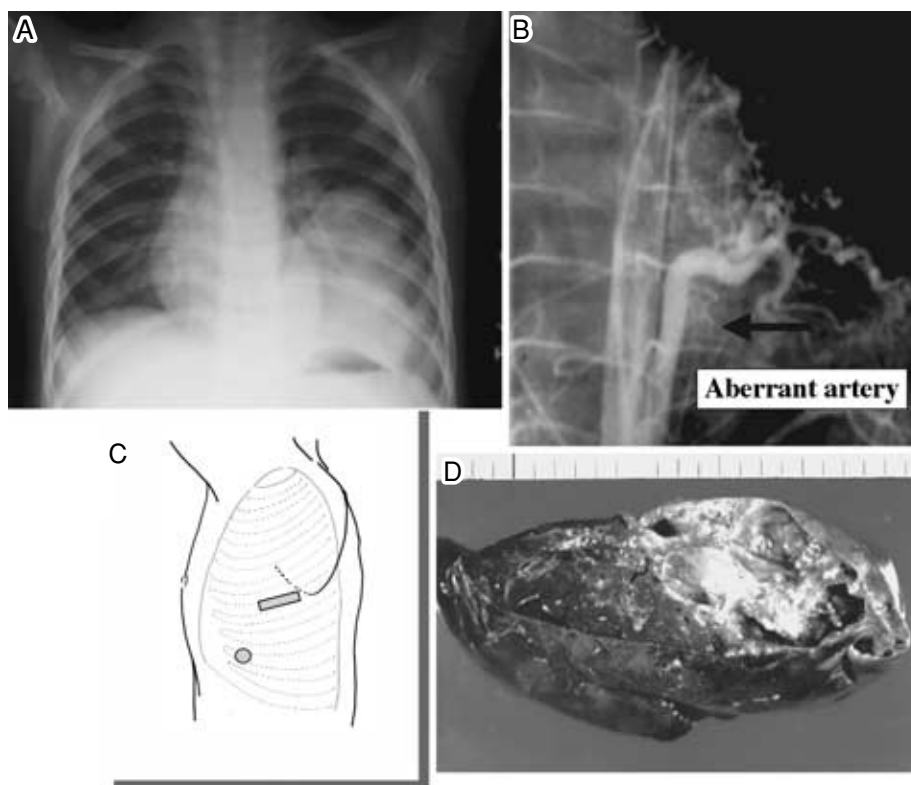


Fig. 4 Patient 4. Intralobar pulmonary sequestration
A, preoperative chest radiography; **B**, preoperative angiography of aberrant artery from abdominal aorta; **C**, position of minithoracotomy and trocar port; **D**, sequestered lung tissue in resected lower lobe.

guided needle biopsy revealed Ewing's sarcoma. Chemotherapy was initiated. The patient was referred to the Division of Thoracic Surgery for the complete removal of the tumor because a marked reduction in tumor size associated with the improvement of paralysis was obtained by chemotherapy. The complete removal of tumor was performed by VATS (**Figs. 6C and D**). The duration of the surgery was 250 minutes and blood loss was 113 ml. An additional radiotherapy with 18 Gy was performed. Five years after the trimodality therapy, the patient has been enjoying ordinary life without the recurrence of the tumor.

Discussion

With the improvement in surgical techniques and endoscopic instruments, thoracoscopic surgery has been performed in children and adolescents. Since Rodgers et al.¹, in 1979, reported the efficacy of the thoracoscopic surgical approach in children, the

advantages of thoracoscopy have been noted particularly in terms of diagnostic accuracy and therapeutic strategy²⁻⁷. The advantage of thoracoscopic surgery may be its minimal invasiveness in its approach to the thorax. From 1992 to 2003, we performed thoracoscopic surgery on 977 patients. We have investigated the efficacy of this minimally invasive approach in terms of functional and oncological benefits¹⁵⁻¹⁷. Therefore, we have extended surgical indications in children and adolescents on the basis of results of prior studies.

Safety of thoracoscopic approaches: In the present series, surgery-related factors, (i.e., average duration of thoracostomy tube drainage, and average duration of postoperative hospitalization), were similar to those previously reported⁸. There was no morbidity or mortality associated with thoracoscopic procedures and none of the patients required a conversion to conventional thoracotomy. Although, during anesthesia, selective one-lung ventilation was not possible in infants, it was possible in older

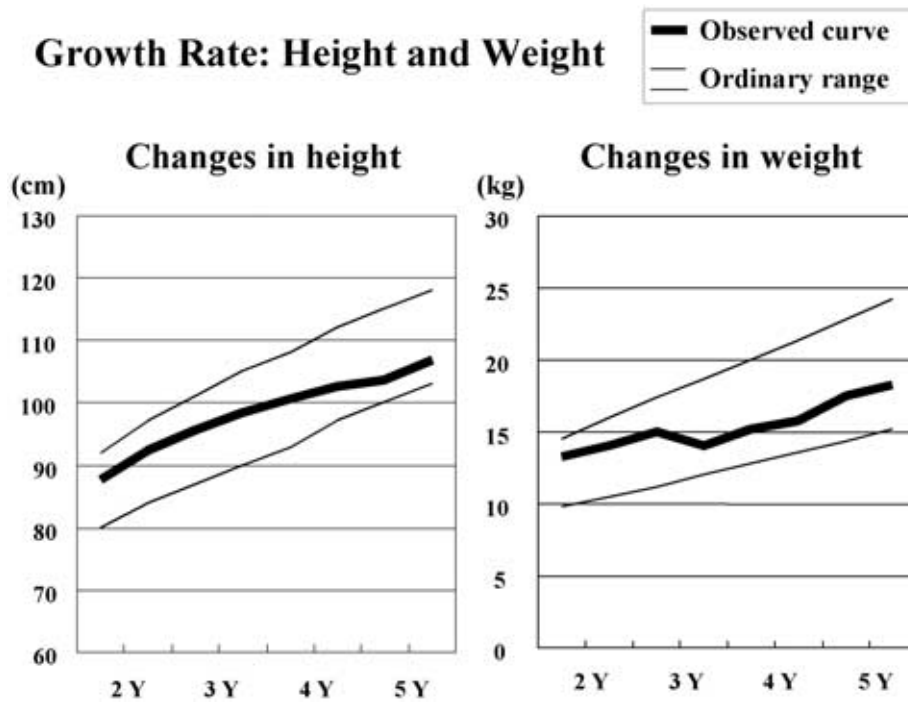


Fig. 5 Growth rate curve in Patient 4

The patient was completely cured of the symptoms and showed the normal growth rate in height and weight for 4 years postoperatively.

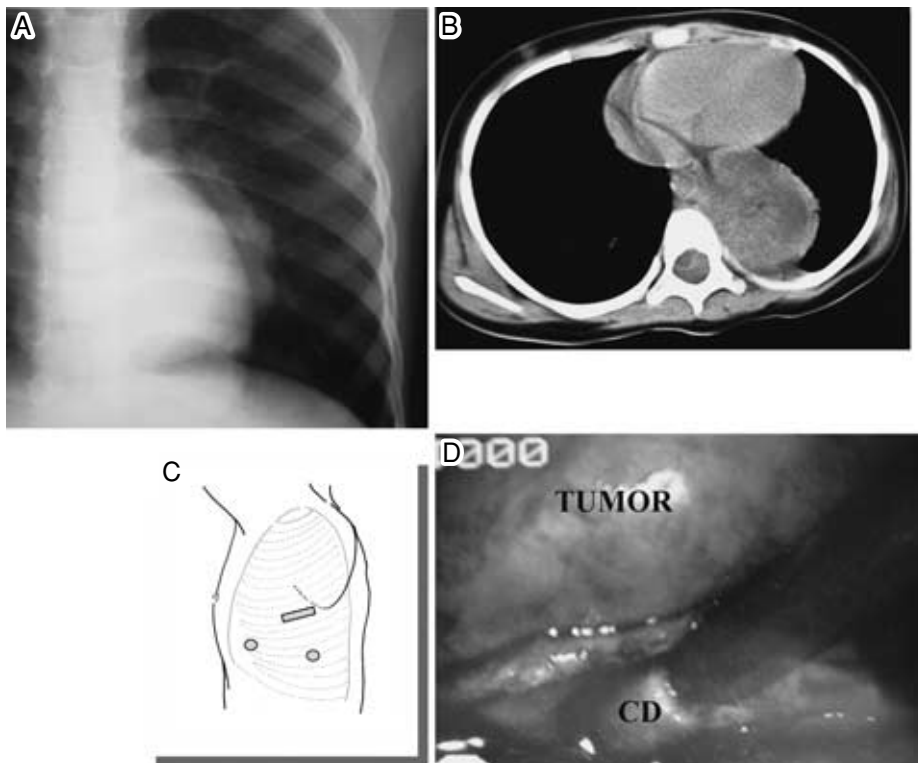


Fig. 6 Patient 5. Mediastinal Ewing's sarcoma

A, preoperative chest radiography; B, preoperative chest CT; C, site of minithoracotomy and trocar ports; D, thoracoscopic view of tumor indicated by 5-mm-diameter cotton dissector.

children. In some patients, an endotracheal tube was inserted into the contralateral main bronchus to achieve ipsilateral lung collapse. The coordination of the anesthetist was important. Furthermore, small endoscopic instruments were necessary.

Indication of thoracoscopic procedures: Seventy-one children and adolescents underwent 74 thoracoscopic procedures as diagnostic and therapeutic strategies for various chest diseases. As for the diagnostic and therapeutic aspects, in the case of diffuse pulmonary diseases, lung biopsy was reported to be useful in making a correct diagnosis, which allows the immediate initiation of treatment⁸⁻¹⁰. Patient 2 (a 1-year-old girl) is a typical case in which a rapid diagnosis and an early initiation of an appropriate treatment was carried out. Lobectomy by VATS has been controversial in terms of its indications, but, its efficacy of managing benign lung diseases in adults except malignant diseases is established. In 2003, Rothenberg⁹ and Albenese et al.¹⁰ reported the safety and efficacy of VATS lobectomy even in infants and children, whose diagnosis included pulmonary sequestration, congenital adenomatoid malformation, severe bronchiectasis, congenital lobar emphysema and malignancy. They emphasized the prevention of the inherent morbidity of a major thoracotomy incision and a reduction in pain resulting in early recovery with a short hospitalization. Patient 4 (a 1-year-old boy) showed no deterioration in the growth rate for 4 years after left lower lobectomy by VATS. Our prior investigation concerning the merits and demerits of VATS lobectomy in adults, suggested the advantages of the procedure in terms of the function and healing degree over conventional thoracotomy¹⁵⁻¹⁷. Therefore further refinement of training on its technical aspects is required.

Thoracoscopic procedure might be superior in managing mediastinal diseases. Although Michel et al.¹¹ mentioned the thoracoscopic excision of mediastinal cysts, they were concerned with the feasibility and difficulty of the surgical technique. They advised surgeons to convert from thoracoscopic surgery to conventional thoracotomy in cases of infection, very large cysts, and when cysts are located near the carina, tracheal mucosa,

and esophagus. In our experience, a huge mediastinal bronchogenic cyst in Patient 3 (a 5-year-old girl) was easily excised by TS by reducing the volume of the cyst by fine-needle aspiration as recommended by pioneers^{11,12}. Benign neurogenic tumors and palmar hyperhidrosis are good candidates for TS.

The decision on the diagnostic and therapeutic strategies for malignant diseases is important. However, thoracoscopic surgery is still controversial for malignant diseases. The efficacy of trimodality therapy including prospective chemotherapies/radiotherapy/surgical treatment for mediastinal malignant tumors seems to support the efficacy of the thoracoscopic approach^{4,8}. In the treatment of malignant chest diseases in particular, the thoracoscopic approach was reported to be useful in establishing a rapid and reliable diagnosis, and an appropriate treatment strategy^{4,8}. Regarding these advantages, Smith et al.¹³ emphasized that the rapid postoperative recovery after VATS permits patients to undergo an immediate postoperative chemoradiotherapy in comparison with thoracotomy. A tumor less than 8 cm in diameter without metastasis is considered to be a prognosticator of effective chemoradiotherapy followed by surgery⁹⁻¹¹. Patient 5 (a 3-year-old girl) had a tumor 5 cm in diameter without metastasis. This patient achieved tumor size reduction and improvement in the paraplegia of the lower limbs. When chemotherapy can reduce tumor size and improve symptoms, VATS could be considered as a treatment option for localized mediastinal tumor.

We reviewed our experience in thoracoscopic surgery and the problems encountered during this procedure, focusing on infants less than 6 years old among 71 children and adolescents who underwent thoracoscopic procedures. All the patients could have a surgery without conversion to conventional thoracotomy and there has been no mortality or morbidity related to the thoracoscopic procedures.

Conclusions

We considered that the thoracoscopic approach offers a rapid and simple method of therapeutic

diagnosis and surgical treatment for children and adolescents. However, children less than 6 years old required the specific maintenance of ventilation during anesthesia and specific instruments for surgery compared with older children and adolescents. Cosmetic benefits were also obtained for girls. However, the most important consideration is the decision on a treatment strategy based on the coordination by both the pediatrician and a thoracic surgeon.

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