

ORIGINAL ARTICLE

Analysis of 50 cases of operated giant thoracic tumors

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Summary

Purpose: To study the experience of the surgical treatment of giant thoracic tumors and the ways to overcome intraoperative and postoperative difficulties.

Methods: A retrospective analysis of the data from 50 patients operated with giant thoracic tumors (26 men and 24 women; age range 0.5-77 years) was carried out. All patients were treated with different surgical resections. The resected tumors weighed between 628 and 2586 g (mean 1973) and the intraoperative blood loss was 400 -1500 ml.

Results: The tumor was successfully resected in all patients. Forty-eight (96%) patients were treated and discharged after the operation. Two (4%) patients developed postoperative pulmonary edema; one of them died due to disseminated intravascular coagulation (DIC) and the other one was discharged after full recovery. During follow up, one patient died of an abdominal metastasis of malignant mesothelioma 1 year after operation, and another one with mature

teratoma died 4 months after the operation but the cause of death was unknown. The success of surgical resection was not related to the pathological tumor type. The surgical treatment was determined by the invasion and distant metastasis of giant thoracic tumors and surrounding tissues.

Conclusions: Patients with giant thoracic tumors often have severe symptoms that cannot be managed with conservative treatment. However, surgery can completely resolve the symptoms. In order to fully reveal the operative field, the incision has to be as close as possible to the tumor. Various surgical techniques, such as complete, segmented, or major portion incisions, can be used, and attention should be paid to avoid major intraoperative bleeding. Preventive measures against re-expansion pulmonary edema should be applied as soon as possible after the surgery.

Key words: surgery, giant tumors, thoracic

Introduction

The thoracic and mediastinal cavities contain many important organs, with relatively complex anatomical structures. Tumors at these sites often occupy the mediastinum or the pleural cavity and can easily compress the trachea, heart, large vessels, and other adjacent organs, causing serious clinical symptoms [1]. Currently, there is no uniform standard to guide the therapeutic management of giant thoracic tumors, which are clinically rare, and are mostly seen as case reports in the literature.

Giant thoracic tumors come in a variety of

pathological types and the preoperative diagnosis is often difficult [2]. Their clinical symptoms are severe or even life-threatening, and therefore surgical resection to remove the tumor and relieve the compression of vital organs is the most effective way of treating such situations [3,4]. However, these operations are complex, with high technical difficulties and risks, and the postoperative complications are relatively high, especially those due to anesthesia. Different surgical techniques and postoperative care lead to different outcomes of general thoracic tumor resections.

Fifty patients with giant thoracic tumors were surgically treated at our hospital from June 2010 to June 2013 and in all of them treatment was successful the details of which are reported below.

Methods

Patients

This study was conducted in accordance with the declaration of Helsinki and after approval from the Ethics Committee of the General Hospital of Chinese People's Liberation Army and the First Affiliated Hospital of the General Hospital of People's Liberation Army. Written informed consent was obtained from all participants.

Among the 50 patients, there were 26 men and 24 women, aged 0.5-77 years (mean 44.55). Sixteen patients (32%) were asymptomatic, and were treated after being diagnosed upon physical examination; 34 patients (68%) were symptomatic, and showed various degrees of chest tightness, shortness of breath, and sputum or hemoptysis, as well as shifting of the trachea or jugular vein distention due to compression from the tumor.

Surgical approaches

Benign tumors that did not fill the entire thoracic cavity and without apparent invasion were completely resected. Huge solid tumors that occupied the chest were removed using the segmented method, and huge cystic tumors, including cystic teratoma, were first decompressed and had the capsule liquid aspirated, followed by resection. The patients were followed up for 0.5-3 years.

Statistics

All statistical analyses were carried out using SPSS 17.0 software (SPSS Inc., Chicago, Ill, USA).

The comparison of the age distribution between the clinically symptomatic group and the clinically asymptomatic group met the requirements for a normal distribution and was quantitative. Student's t-test was used for comparisons. A p value <0.05 was considered statistically significant.

Results

General characteristics of giant thoracic tumors

No significant difference was noticed in age distribution between the clinical symptomatic and non-symptomatic group (Table 1; $p=0.676$). Twenty-seven (54%) of 50 patients had pulmonary dysfunction, 24 (48%) had an abnormal electrocardiogram (ECG), and 3 (6%) had superior vena

cava obstruction. In 14 (28%) cases, the main tumor body was located in the left chest, in 22 (44%) cases in the right chest, 2 (4%) cases had bilateral chest locations, and in 12 (24%) cases the tumor was located in the mediastinal cavity. Of the mediastinal tumors, in 5 (10%) cases the tumor occupied the entire side of chest, and in 9 (18%) the tumor occupied over one-half of one side of the chest. Mediastinal tumors were registered in 48 (96%) patients and in 2 patients the tumor originated from the pleura; 38 (76%) of the cases were benign tumors, and the other 12 (24%) were malignant. By far, the most frequent tumor was thymoma, followed by mature teratoma (Table 2). The patients were followed up for 0.5-3 years.

The resected tumors weighed 628-2586 g (mean 1973) and the intraoperative blood loss was 400-1500 ml. The minimum tumor size was 9×10×8cm, and the maximum was 20×15×15cm (Figure 1).

In 2 (4%) cases, the tumor occupied the entire side of the chest, causing the mediastinum to shift contralaterally, and fully compressing the lung, resulting in loss of its respiratory function. In one case, the tumor occupied both sides of the chest, mainly on the left side, and compressed the mediastinum towards the spine. The remaining 47 patients (94%) had tumors that occupied more than half of the volume of one side of the chest, and had various symptoms of heart or pulmonary insufficiency. The patients in this case series had no surgical contraindications.

Clinical symptoms

Figure 2 shows the frequency of the different clinical symptoms. Feeling of chest compression and chest pain prevailed.

Of note, a considerable number of patients were asymptomatic.

Outcome of surgery

In 2 (4%) cases, postoperative re-expansion pulmonary edema occurred; of these, one patient died due to DIC, and the other one was discharged after full recovery from the treatment. All of the remaining patients had full recovery and were discharged. During follow-up, one patient died of an abdominal metastasis of malignant mesothelioma 1 year after the operation, and one patient treated for a mature teratoma died 4 months after the operation, but the cause of death was unknown. The remaining patients were followed up

Table 1. No statistically significant difference in the age distribution of the symptomatic and the asymptomatic groups

Group	t	df	p value	Average difference	SD	95%CI
Symptomatic and asymptomatic groups	0.420	48	0.676	2.224	5.298	-8.43-12.88

**Figure 1.** Complete surgical resection of a malignant pleural mesothelioma measuring 20×15×15 cm.

until now, and all have survived and seem healthy (Figure 3A and 3B).

Surgery selection for patients

In one case with malignant thymoma the tumor invaded the pericardium, so the tumor along with part of the pericardium were resected together. One case of malignant mesothelioma infringed the entire left lung and the left side of the diaphragm, so the tumor along with the left lung and diaphragm were all resected, and the diaphragm was mesh-repaired later.

In total, 43 (86%) cases were completely resected, and 7 (14%) cases had the major portion of the tumors removed; 46 (92%) cases had simple tumor excisions, one case had resection of the superior vena cava and innominate vein angioplasty

Table 2. General patient and giant thoracic tumors characteristics

General characteristics	N (%)
Age (years, mean ± standard deviation)	44.55 ± 17.328
Sex	
Male	26 (52.00)
Female	24 (48.00)
Tumor origin	
Mediastinum	48 (46.00)
Pleural cavity	2 (4.00)
Pathological types	
Thymic hyperplasia	1 (2.00)
Thymus cyst	1 (2.00)
Thymoma	16 (32.00)
Thymic carcinoma	5 (10.00)
Mature teratoma	6 (12.00)
Immature teratoma	2 (4.00)
Ganglioneuroma	2 (4.00)
Solitary fibrous tumor	3 (6.00)
Malignant solitary fibrous tumor	1 (2.00)
Spindle cell neurogenic tumor	1 (2.00)
Neuroblastoma	1 (2.00)
Nodular goiter	1 (2.00)
Neurinoma	3 (6.00)
Neurinosarcoma	1 (2.00)
Inflammatory myofibroblastic tumor	1 (2.00)
Primitive neuroectodermal tumor	1 (2.00)
Mixed germ cell tumor	1 (2.00)
Chondroma	1 (2.00)
Malignant pleural mesothelioma	2 (4.00)
Benign or malignant	
Benign	38 (76.00)
Malignant	12 (24.00)

performed simultaneously, and 3 (6%) cases were subjected to pulmonary resection.

Longitudinal sternotomy approach was used in 8 (16%) cases, and side chest incisions were

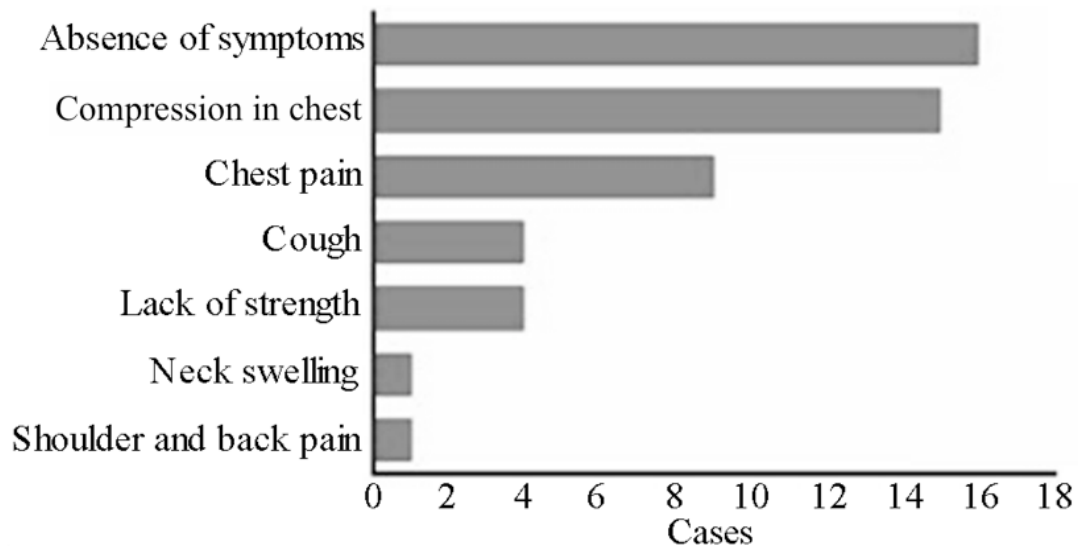


Figure 2. Characteristic distribution of clinical symptoms.

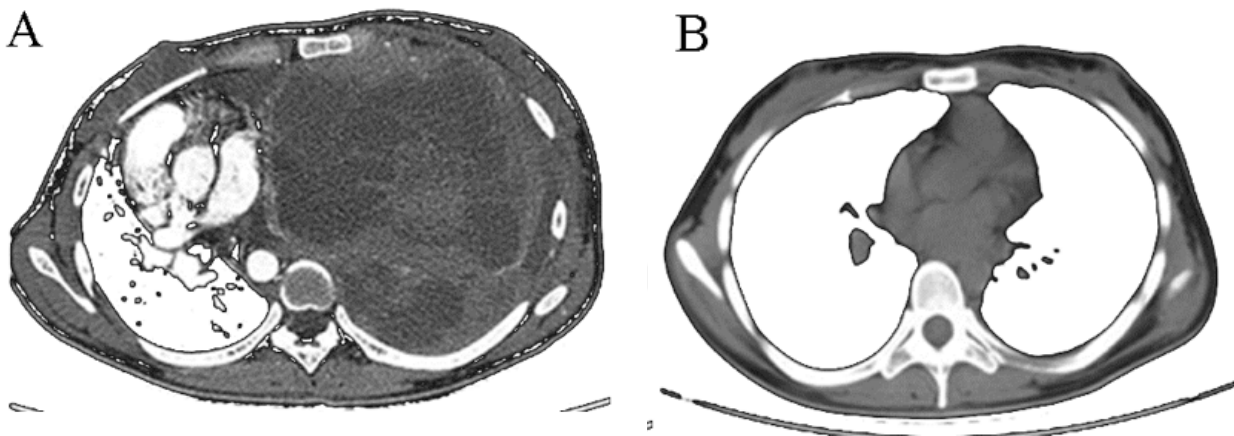


Figure 3. A case of malignant pleural mesothelioma. Comparison of preoperative and postoperative CT scan. **A:** Preoperative chest CT shows a giant tumor on the left chest; **B:** Postoperative chest CT examination one month after resection.

performed in 39 (78%) cases. Unilateral chest incision plus a transverse sternotomy, unilateral chest incision plus a transverse clavicle incision and a cervical transverse incision were used in one case each.

Discussion

The 50 cases in this group consisted of a wide variety of different tumors discussed below:

1. Mediastinal teratoma consists 20% of all mediastinal tumors in children, which can occur at any age from newborns to adolescents. These tumors most often arise from the anterior mediastinum, and the proportion of affected men and women is even.

The clinical symptoms include respiratory distress, chronic cough, chest pain or wheezing, and occasionally coughing up hair if the tumor breaks into the bronchi. A chest radiography and computed tomography (CT) scanning can aid in the diagnosis. The first choice of treatment is surgical resection of the tumor, with the addition of postoperative chemotherapy for malignant teratomas. Combination chemotherapy of etoposide (VP-16), bleomycin, and cisplatin has good chemotherapeutic efficacy. The 4-year survival rate is 71% [6].

2. Paraganglioma is the most common childhood mediastinal neurogenic tumor. These tumors only gradually increase in size, and often have a complete capsule. The clinical symptoms are mostly mild, and the chest CT may reveal spot-

ting and morphological calcification inside the substance mass [7,8]. The first choice of treatment is surgical removal of the tumor.

3. Malignant schwannoma is rare [9]. There is a report of a rare thymus origin within the chest cavity. This tumor type has low degree of malignancy, and full resections can be performed on patients who have complete capsules with beneficial effects. However, if the histological characteristics of vasculature differentiation or striated muscle neuroblastoma tumor appear, there is a high degree of malignancy, and the prognosis is poor.

4. Neuroblastoma is an embryonic tumor derived from the neural crest, accounting for 7-10% of childhood malignancies; 20% originate from the posterior mediastinum [10], and the clinical manifestations progress rapidly. They are often misdiagnosed, and surgical resection has an important role in their treatment.

5. Spindle cell carcinoma is a type of limited pleural mesothelioma, but less common, and occurs mostly in 40 to 50 year-old adults. No obvious symptoms appear in the early stages, but symptoms such as chest pain, shortness of breath, and coughing can appear with increasing size of the tumor. They are often found on chest radiography examination. Benign cases are mainly composed of fibers, which are the spindle cells, along with occasional epithelial cells. When the major component of the tumor is epithelial cells, it can indicate malignant behavior.

6. Mesenchymal chondrosarcoma (MCS) accounts for about 3-10% of all sarcomas, occurring in the bones and soft tissues. It usually occurs in individuals aged 21 to 58 years, and the male to female ratio is about 2:1 [11]. The patients have no specific symptoms in the early onset period but there can be increasing compression symptoms corresponding with an increase of the mass. The diagnosis relies on pathological examinations. The first choice of treatment is wide excision, and the role of chemotherapy is still unclear. The 10-year survival rate is less than 50% [12].

Giant thoracic tumors are mostly benign, but when their expansive growth reaches a certain level they can cause a mediastinal shift, compressing the heart, lungs, and large vessels to cause respiratory and circulatory dysfunction (Figure 3A). Only the appearance of specific symptoms leads to their discovery, and the literature has shown that there has been an increase in the number of patients with no clinical symptoms of primary

mediastinal malignancies in recent years [13].

The common symptoms are difficulty in breathing, chest pain, chest tightness, cough, palpitation, and shortness of breath. Most malignant tumors tend to invade the surrounding tissues or develop distant metastases prior to their development into giant thoracic tumors. Those patients that have invasion of the surrounding tissues are evaluated for surgical treatment based on the severity of their condition and the extent of the invasion.

Patients with severe symptoms can be considered for palliative tumor resection, mainly for the relief of compression symptoms. There were two cases of this type in the current study group.

A number of radiation - and chemotherapy-sensitive malignant tumors did not meet the surgical treatment requirements for inclusion in this study group, for example, lymphoma, germ cell tumors, etc. Currently, the diagnostic criteria for a giant thoracic tumor has not been standardized, and a diagnosis based simply on the size or weight of the tumor alone would not be appropriate. The diagnosis should be based on the patient's age, volume of the chest occupied by the tumor, the impact on heart and lung function, and other factors.

After referring to the available literature, the giant thoracic tumors in this study were diagnosed based on the criteria of mediastinal tumors occupying more than 1/2 of one side of the chest, with the patients experiencing pulmonary insufficiency symptoms due to the influence from the tumors; or the tumor occupied one side of the chest, with a contralateral mediastinal shift, and one side of the lung was fully compressed and therefore had no respiratory function [14].

Due to the expansive growth characteristics of benign tumors, the early symptoms were usually not obvious, and occurred only when the tumor grew to a certain extent, compressing the adjacent organs, leading to a series of specific clinical symptoms. These included the characteristic chest tightness, suffocation, shortness of breath, etc. Radiographic findings were often atypical, and sometimes it would be difficult to distinguish tumors from large pleural effusions. Two cases in the study group had been previously misdiagnosed by other hospitals as tuberculous pleurisy, and the long-term chest fluid pumping, anti-inflammatory, and anti-tuberculosis treatments administered did not improve their conditions.

From the analysis of this set of data, we realized that: 1) The chest CT examination is still the main diagnostic method, especially enhanced

CT that can further clarify the tumor's relationship with the heart and large vessels, and also determine the intratumoral blood flow. 2) Magnetic resonance imaging (MRI) is useful when the tumor was closely related to the spine to clarify whether the nerves are involved. 3) Preoperative examinations of AFP and HCG can help to further determine the nature of the tumor (germ-cell tumor). 4) Percutaneous biopsy is not routinely recommended, since the biopsy can easily lead to accidental hemorrhage of the tumor or injury of the intrathoracic vessels, which can cause fatal accidents. 5) Malignant pleural effusions can occur; and a giant benign tumor can also form benign effusions. Therefore, the preoperative diagnosis should be as thorough as possible, and the possibility of a complete resection should be considered for malignancies [15].

The conventional balanced intravenous anesthesia, particularly after the use of muscle relaxants, causes a decreased tension of the tumor-surrounding tissues, and the resulting increased pressure on blood vessels and trachea could lead to a drop in blood pressure, leading to serious complications such as suffocation and shock, so an awake intubation should be used when necessary [16].

The awake intubation through the nose under the single-lumen endotracheal method was used for all of the patients in this case series. This placement reduces the irritation caused by the intubation, and the tube can be taken back to the wards for mechanical ventilation usage. Muscle relaxants should be used as little as possible, the induction time should be short, the intubation should be quick, and the vital signs should be closely monitored [17]. The intraoperative anesthesia should not be too deep.

If the mediastinal or tracheal shifts make intubation difficult, a bronchoscopy-guided intubation could be used. The patient's body should be slowly placed into position after the anesthesia, and the thoracotomy should be performed immediately after the positioning to reduce the tumor compression time towards the heart and other vital organs. In our series, two cases of hypotension occurred after anesthesia, but the blood pressure was restored after the intravenous injection of dopamine. Some authors advocate the change of the body position to reduce tumor compression to blood vessels and trachea, so that such complications can be avoided during anesthesia [18].

The choice of the incision primarily depends on the size and location of the tumor. The main

principles are to ensure a sufficient surgical field exposure and safety of the operation, without worrying about the size of the incision. For patients with centered anterior mediastinal tumors, especially those with tumors closely related to the innominate vein, the surgeon should adopt the longitudinal sternotomy incision to ensure an adequate exposure of the operative field and the safety of the operation. In addition, this achieves a good exposure for those requiring vein grafting due to infringement on the innominate vein.

As for patients with tumors in the anterior mediastinum deviating towards one side of the chest, the anterolateral incisions of the lateral supine position, or ipsilateral external incisions after elevating the lateral side of the patients could be used, and it could reduce the tumor compression on the organs. For patients with tumors protruding into one side of the chest the surgeon could choose the lateral incision, and the ribs could be cut in order to further expand the operative field when necessary. The surgeons used this type of incision for the majority of the patients in the current case series group.

For patients with tumors in the anterior mediastinum deviating towards the bilateral pleura, the surgeon could use the lateral position-antrolateral transverse incision on the sternum, so that both sides of the chest can be taken care of. One patient in the current group had the tumor in the anterior mediastinum and prominent to the bilateral pleura, so a transverse sternal incision with a unilateral elevation was performed to fully expose the surgical field.

The posterolateral incision was performed for removal of the middle and posterior mediastinal tumors, which could fully reveal the relationship of the tumor with the neighboring organs and facilitate the surgical procedure, reduce the complication rate, and improve the removal rate. The posterolateral incision was used in 5 cases in this group. A combination of posterolateral and clavicular joint incisions were used to complete the tumor resection in one case of schwannoma. No standardized guidelines exist for the resection of giant mediastinal tumors, but we developed the following based on our clinical experience: 1) Due to the large tumor size of giant thoracic tumors, the heart and the blood vessels are compressed, thus minimizing the intraoperative pressure towards the tumor can help avoid any additional compression on the heart. 2) Tumor dissociation is normally hard to achieve due to the lack of gaps in large tumors, therefore tumor depressurization

and shrinkage for cystic or solid tumors could be performed prior to the surgical resection. For solid tumors, a segmented removal approach could be used, starting from reducing the heart compression, next removing the major portion of the tumor, and then the remaining portions of the tumor can be removed once the surgical field is clear. 3) As for patients with tumor invasion or difficulties in separating the tumor tissue from the surrounding vital organs, blind sharp excisions or violent separations should be avoided; complete resections are not compulsory, and the residual tumor can be cauterized with an electric knife, as well as with postoperative radiotherapy. 4) Intraoperative bleeding should be controlled as much as possible, an ample supply of blood and intravenous pathways should be prepared preoperatively, and autologous blood transfusion machine should be prepared for intraoperative use. 5) If heavy bleeding occurs for encapsulated tumors and tumors that are close to the heart and large vessels but without adhesions, the method of bare stripping the tumor capsule, with quick removal and then hemostasis should be used. 6) The lung tissues, that were long-term compressed, might re-extend after the tumors are resected. 7) The principles of "leave no tumor" should be followed, and the tumor tissue's growth or transfer caused by surgical disturbance should be minimized. During surgery, warm distilled water can be used to wash the thoracic cavity, and chemotherapy drugs can be used inside the thoracic cavity to prevent pleural tumor metastasis or growth.

Complications are prone to occur after giant thoracic tumor operations, and the key to a successful rehabilitation is early detection and treatment. 1) The patients would often experience a large surgical trauma, coupled with sudden release of long-term compression on the heart and lungs caused by the tumors, and therefore

short-term heart and lung functional abnormalities could easily occur. To be safe, the patients should return to the wards in a sedated state with endotracheal intubation and mechanical ventilation, which can help the patients get through the postoperative risk period. 2) The extended compression of the tumor on the cardiac vessels, coupled with major intraoperative bleeding, oozing, and sustained fluid transfusion, can easily lead to concurrent postoperative left ventricular failure, which should be treated with prompt cardiac, diuretic, vasodilation, and other treatments, particularly the replenishment of colloid solutions. 3) Since re-expansive pulmonary edema is related to the time and the degree of lung collapse, as well as to the speed of pulmonary re-expansion, its occurrence might be related to the increased permeability of the pulmonary capillaries after re-expansion, that were originally in a state of hypoxia [19]. Therefore, particular attention should be paid to the slow re-expansion of extensively compressed lungs, and an adequate supply of oxygen and control of the chest drainage can effectively prevent any re-expansion pulmonary edema. Mechanical ventilation could be used postoperatively to assist in breathing, and a pressure-controlled mode with a pressure of end-breath as positive 8 H₂O-10cm could improve any pulmonary edema, accompanied with regular and timely suctions, strict limitation of fluid supplementation, and corrections of hypoproteinemia. Glucocorticoids, cardiac and diuretic drugs as well as inhalation of prostaglandin E1, could be effective in the treatment of re-expansion pulmonary edema [20].

In summary, after giant thoracic mediastinal tumors are diagnosed, early surgical treatment should be performed in the absence of surgical contraindications to avoid any delay of treatment. Immediate surgery is the best means to improve the patients' survival and quality of life.

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