

Cloward's approach for Pancoast neurogenic tumors: illustrative cases

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BACKGROUND Pancoast tumors are a wide range of tumors located in the apex of the lung. Traditional surgery for Pancoast neurogenic tumors frequently involves extensive approaches, whether anterior or posterior or a combination, in which osteotomies are sometimes required. In this study, the authors proposed a less invasive surgical strategy using the standard Cloward's approach for complete resection of a schwannoma arising from the T1 nerve root.

OBSERVATIONS Two patients, each harboring a large T1 tumor, one on each side, underwent Cloward's approach with and without thoracoscopic surgery. Both patients had complete resection of the tumor. Considering the benign and encapsulated nature of neurogenic tumors, Cloward's approach under neuromonitoring, which is a common procedure for anterior cervical discectomy for most neurosurgeons, is a safe and less invasive alternative for Pancoast neurogenic tumors. For patients whose tumor cannot be removed completely via Cloward's approach, video-assisted thoracoscopic surgery is a viable backup plan with minimal invasiveness.

LESSONS Cloward's approach is a viable option for Pancoast neurogenic tumors.

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KEYWORDS Pancoast tumor; neurogenic tumor; Cloward's approach

Pancoast tumors, or superior sulcus tumors, consist of a wide range of pathologies and are located in the lung apex. Because of the featured anatomical surroundings, delayed diagnosis sometimes occurs. Such a tumor was first described in 1838¹ and later named by Pancoast in 1924.² Pancoast tumors define a wide range of benign or malignant tumors invading portions of the lower brachial plexus, subclavian vessels, vertebral bodies, parietal pleura, apical ribs, and stellate ganglion.^{2,3} Intrathoracic neurogenic tumors accounted for only 28.8% (135/468) of cases in a series reported in 1941.⁴ Most of the tumors are located in the posterior mediastinum along the sheath of the nerves, and some arise from the vertebral canal. Among the benign tumors at the lung apex, neurogenic tumors are most commonly seen in neurosurgical practice.⁵ The characteristic Pancoast-Tobias syndrome includes shoulder and arm pain along the distribution of the eighth cervical nerve trunk and first and second thoracic nerve trunks, Horner syndrome (ptosis, miosis,

and anhidrosis), and weakness and atrophy of the muscles of the hand.^{3,6}

Resection remains the primary treatment for neurogenic tumors.⁷ However, in earlier days, Pancoast tumors were initially thought to be inoperable; the first case of resection was reported in 1956.⁸ In recent decades, commonly adopted surgical approaches have included a high posterolateral approach,⁹ an anterior transcervical-thoracic approach,¹⁰ an anterior transsternal approach,¹¹ and a hemiclammshell or trapdoor approach,¹² all of which inevitably require a large surgical wound, sternotomy, clavicle incision, or resection of ribs.^{13,14}

In the current study, we report on an adaptation of Cloward's approach, which is the common surgical approach used for anterior cervical discectomy and fusion (ACDF) through the avascular plane between the carotid sheath laterally and the larynx and esophagus medially, with or without combining video-assisted thoracoscopic surgery (VATS), for resection of the Pancoast neurogenic tumor.

ABBREVIATIONS ACDF = anterior cervical discectomy and fusion; CUSA = cavitron ultrasonic surgical aspirator; EMG = electromyography; MEP = motor evoked potential; MRI = magnetic resonance imaging; SSEP = somatosensory evoked potential; VATS = video-assisted thoracoscopic surgery.

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Illustrative Cases

Operative Technique

Under general anesthesia, each patient was intubated with a double-lumen endotracheal tube in preparation for backup VATS. Each patient was placed supine, and adequate cushions were applied to keep the neck extended and shoulders abducted (Fig. 1). An incision was made along a horizontal skin crease approximately 2 cm cranial to the clavicle, corresponding to the surgical level over the lesion side. The platysma was cut horizontally. The anterior triangle was dissected to develop the avascular plane between the larynx and esophagus medially and carotid sheath laterally. After caudal blunt dissection, the tumor was identified directly next to the vertebral body. The self-retaining ClearView Titanium Cervical Retractor System (KOROS) was set up to retract the trachea and esophagus medially and the carotid sheath and the sternocleidomastoid laterally.

Central decompression was performed first using a curette or cavitron ultrasonic surgical aspirator (CUSA). The upper pole of the tumor was dissected along the capsule to separate the tumor from the neurovascular structures in the originating neuroforamen. After removing the cranial part of the tumor, dissection was performed to the caudal margin along the tumor capsule while preserving the surrounding brachial plexus. By debulking the tumor piece by piece, it could be pulled out gradually (Fig. 2, Video 1). If complete tumor removal could not be achieved, whether because of a large tumor size or encapsulated vital structures, second-stage VATS could be performed by the thoracic surgeon (Fig. 3, Video 2). The whole procedure was performed under electromyography (EMG), motor evoked potential (MEP), and somatosensory evoked potential (SSEP) neuromonitoring.

VIDEO 1. Clip showing case 1 Cloward's approach for Pancoast neurogenic tumor. Click here to view.

VIDEO 2. Clip showing case 2 second-stage VATS. Click here to view.

Case 1

A 53-year-old woman presented to our facility with right thumb pain and weakness for approximately the last year. Neurological examination showed anhidrosis on the right side of the face, neck, arm, and hand and partial ptosis of the right eyelid, both of which were compatible with Horner syndrome. Using cervical magnetic resonance imaging (MRI), we identified a 4.5-cm, ovoid, well-



FIG. 1. **Left:** The patient was placed supine, with cushions beneath the back and neck to keep the neck extended and shoulders abducted. **Right:** Marked skin incision (*asterisk*) along a horizontal skin crease approximately 2 cm cranial to the clavicle, corresponding to the surgical level over the lesion side. Double lumen endotracheal tube indicated by *arrowhead*.

circumscribed mass extending from the right T1–2 neuroforamen into the apical extrapleural space (Fig. 4). The tumor did not invade the spinal canal. The lesion was slightly heterogeneously enhanced after contrast injection. A nerve conduction study revealed no brachial plexus or peripheral neuropathy over the right side.

Cloward's approach for tumor removal was performed, as mentioned above. The tumor was completely resected after central decompression and dissection from the surrounding fibrotic tissue and pleura. The MEP and SSEP signals were preserved during the entire procedure. A histopathological study reported schwannoma. Complete tumor removal was confirmed by postoperative MRI. The patient's Horner syndrome symptoms slightly improved after tumor resection, and there was no new neurological deficit.

Case 2

A 45-year-old woman had intermittent upper back pain and numbness over the left third to fifth fingers for the last 2 years. Neurological examination showed left-sided Horner syndrome. MRI revealed a 5-cm homogeneously enhanced Pancoast tumor on the left side (Fig. 5). Mild motor axonopathies in the left median and ulnar nerves were demonstrated in a nerve conduction study.

Cloward's approach was performed, but the caudal part of the tumor was too large to be extracted, so the tumor margin was covered with artificial dura as a landmark and the wound was closed. The patient was placed in a lateral position, and the residual tumor was resected completely via second-stage VATS by a thoracic surgeon. The signals of neuromonitoring were stable during the procedures; however, the Horner syndrome symptoms slightly worsened, and the patient experienced new numbness over the ulnar side of the left arm, which persisted for 7 months after surgery. The histopathology indicated schwannoma, and complete tumor removal was confirmed by postoperative MRI.

Discussion

Observations

Traditionally, the surgery for Pancoast tumors has been performed by thoracic surgeons, and the goal has been to resect the tumor and all invaded surrounding structures, including the upper lobe of the lung, ribs, transverse processes of the vertebra, and neural structures. The high posterolateral approach requires a large skin incision, muscle damage, and resection of ribs,⁹ anterior approaches (anterior transcervical-thoracic approach, anterior transsternal approach, and hemiclamsell or trapdoor approach) involve sternotomy and manubrial or clavicle resection.^{10–14} Most neurogenic tumors are slow growing and encapsulate benign neoplasms. Pure extradural extraforaminal neurogenic tumors in the pulmonary apex (Pancoast neurogenic tumors) usually push away rather than invade the surrounding structures, which makes extensive resection of the lung or ribs burdensome.

Cloward's approach was developed in the 1950s.¹⁵ As a common procedure for ACDF among neurosurgeons, Cloward's approach provides wide accessibility from the C2 to T1 level and is known to be safe and effective. The skin incision is hidden in the transverse cervical skin crease, and the avascular plane created by blunt dissection between the carotid sheath and esophagus incurs minimal damage to the cervical muscles. These reasons make Cloward's approach a reasonable choice when considering the resection of Pancoast neurogenic tumors.

Lessons

One of the major concerns about Cloward's approach for Pancoast neurogenic tumors is the probability of complete tumor

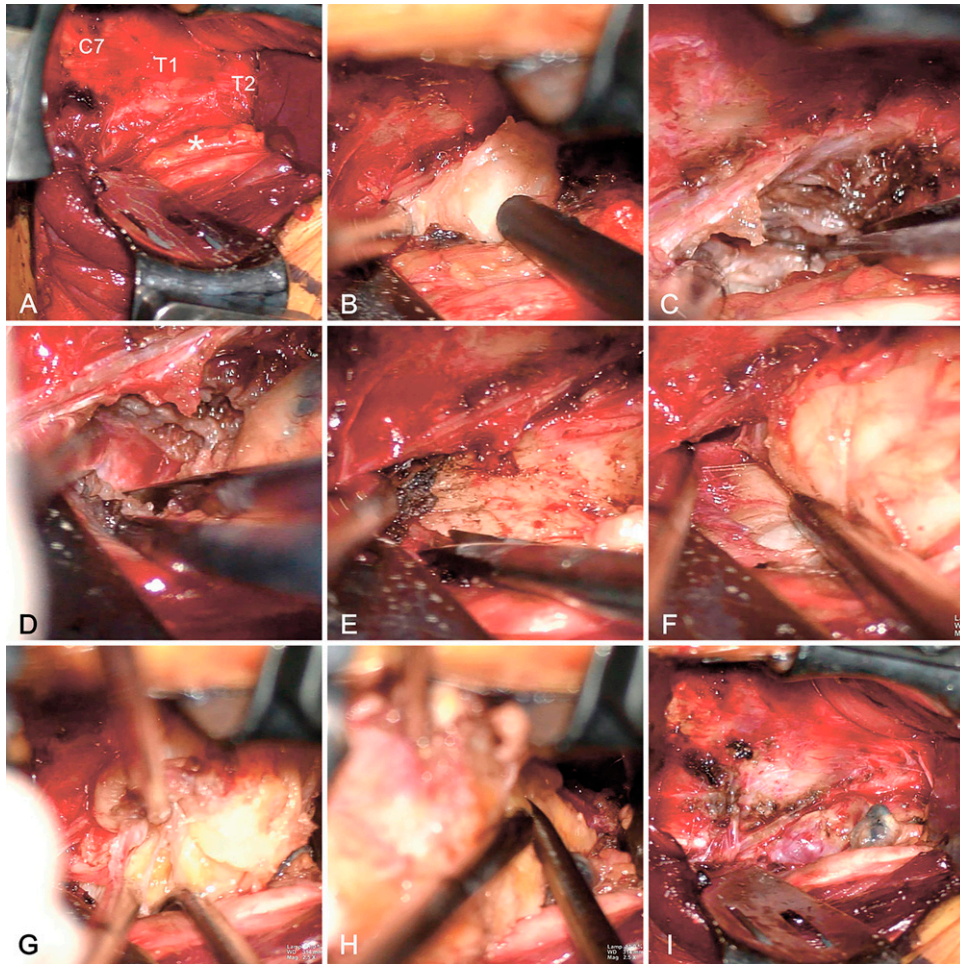


FIG. 2. Surgical procedures in Cloward's approach for right-sided Pancoast neurogenic tumor. After setting the retractors (A), the tumor (asterisk) was identified next to the vertebral body. Central decompression was performed using CUSA (B). The tumor was dissected along the capsule at the medial (C) and cranial (D) sides. The upper pole of the tumor was separated from the originating neuroforamen (E), and the margin was identified (F). Dissection continued at the lateral (G) and caudal (H) sides, and the tumor was removed completely (I).

resection. In the first step, we had to position the retractors in the proper location; sometimes the tumor was not easily visible, so we used intraoperative fluoroscopy to confirm the level of retractors, which is similar to what we do in cervical spine surgery. Most of the neurogenic tumors are rubbery and well circumscribed, so after central decompression, the tumor can be dissected along the capsule and extracted gradually. Sometimes it is easier for the surgeon to stand on the opposite side to dissect the lateral portion. We even tried to operate on a non-neurogenic tumor, but the tumor was too firm and too attached to the surrounding tissue, which made dissection impossible. If total removal is not achievable via Cloward's approach, after resecting the tumor origin in the neuroforamen, the residual caudal portion can be removed by a thoracic surgeon via second-stage VATS, which is also a minimally invasive surgery with small incisions and little structural damage. However, if the tumor invades the spinal canal or even the intradural space, a posterior approach for tumor resection may be inevitable.

We chose double-lumen endotracheal intubation in preparation for possible second-stage VATS. The use of a double-lumen endotracheal tube enabled one-lung ventilation by deflating the surgical-side lung during surgery and provided an immobilized surgical field, which is

fundamental in minimally invasive thoracic surgery.¹⁵ It was also feasible for the patient to have traditional single-lumen endotracheal intubation initially, and then we could change to a double-lumen endotracheal tube if second-stage VATS was necessary.

As for possible complications, we must be aware of brachial plexus or sympathetic chain damage during tumor dissection. In our cases, surgical procedures were performed under intraoperative EMG, MEP, and SSEP monitoring. Dissection must be done carefully, and surgery should be stopped once the signals decrease. Horner syndrome as a surgical complication was found in 0.2% to 4% of patients undergoing anterior cervical spine surgery¹⁶ and in 1.3% of patients after thoracic surgery.¹⁷ The prognosis of Horner syndrome depends on its etiology. The reported data in thoracic surgery showed 57% to 66% complete or incomplete recovery after indirect injury.^{17,18} Therefore, it is necessary to avoid damaging the cervical sympathetic chain during a surgical procedure or to decrease the use of cauterization on the tumor capsule.

Other possible complications for resection of Pancoast tumors include hemothorax resulting from extensive pleural adhesion, injury to the subclavian artery or vein, venous oozing from the neural foramen, and chylothorax after damage to the thoracic duct when manipulating

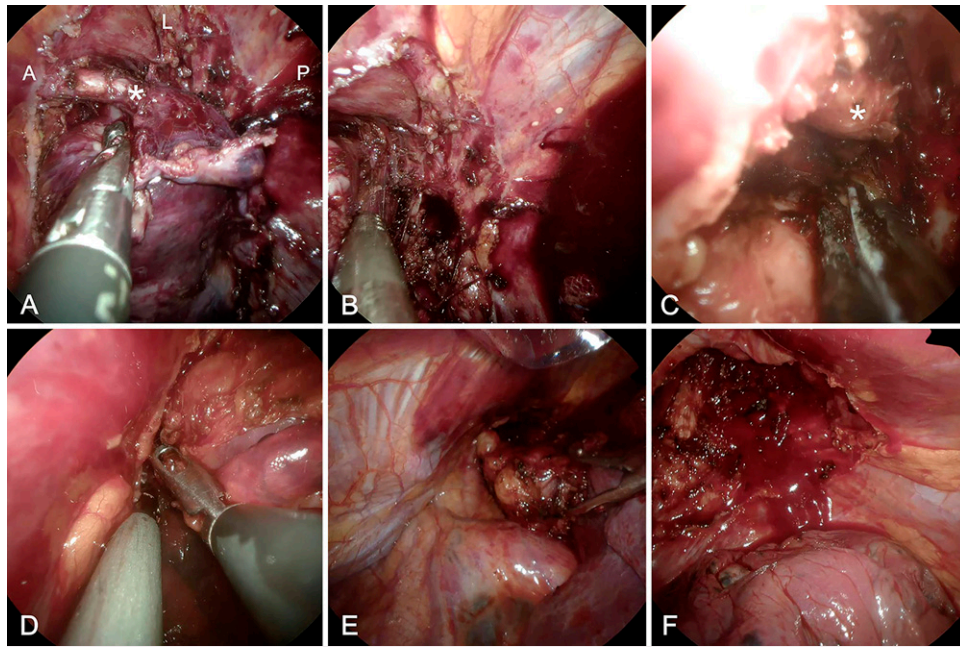


FIG. 3. Surgical procedures in VATS for a left-sided Pancoast neurogenic tumor after partial resection via the anterior cervical approach. After dissection (**A and B**), the originating root (*asterisks*) was cut (**C**). The tumor was freed from the chest wall (**D and E**) and removed totally (**F**). A = anterior; L = left; P = posterior.

left-sided tumors. To prevent these complications, special attention must be given during blunt dissection at the border and pulling out the tumor. However, Cloward's approach is still a reasonable choice for Pancoast neurogenic tumors that are minimally invasive.

In conclusion, Cloward's approach is a viable choice for Pancoast neurogenic tumors. Complete tumor resection under neuro-monitoring can be achieved with or sometimes without VATS. Cooperation with thoracic surgeons is suggested as a backup plan.

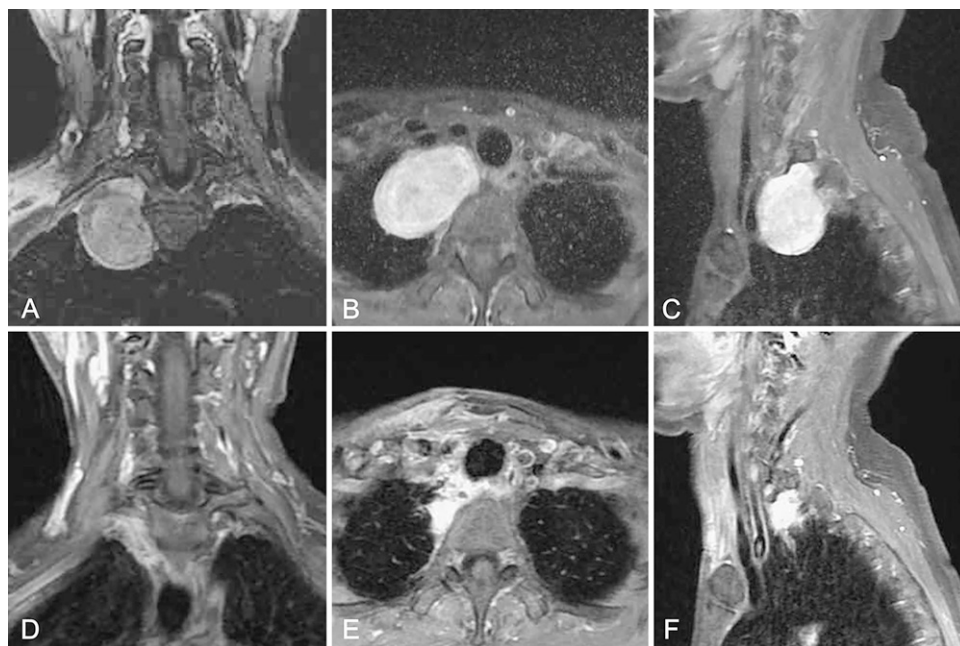


FIG. 4. Contrast-enhanced T1-weighted MRI in case 1. Preoperative images (**A–C**) revealed an ovoid, well-circumscribed, well-enhanced mass lesion at the right lung apex, with extension from the right T1–2 neuroforamen. Two months after surgery, there was no residual tumor, only fibrotic tissue (**D–F**). Coronal (**A and D**), axial (**B and E**), and sagittal (**C and F**) views.

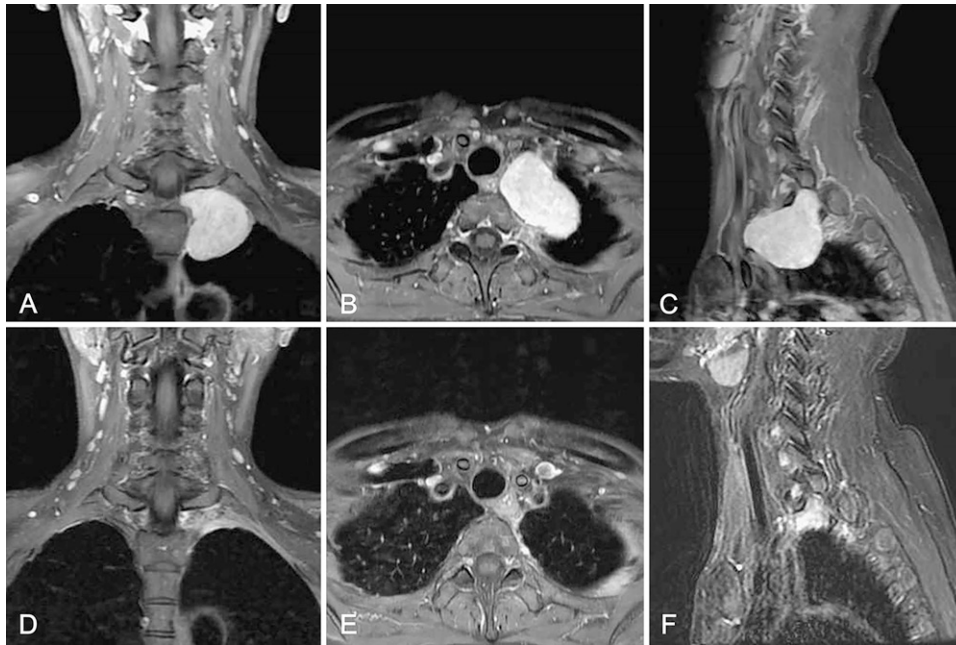


FIG. 5. Contrast-enhanced T1-weighted MRI in case 2. A left-sided Pancoast neurogenic tumor was identified on preoperative images (A–C), and complete resection was confirmed on postoperative MRI scans 3 months after surgery (D–F). Coronal (A and D), axial (B and E), and sagittal (C and F) views.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Tu, Wu, Huang. Acquisition of data: Kuo, Huang. Analysis and interpretation of data: Kuo. Drafting the article: Kuo, Wu. Critically revising the article: Tu, Wu. Reviewed submitted version of manuscript: Tu, Wu. Approved the final version of the manuscript on behalf of all authors: Tu. Administrative/technical/material support: Hsu, Wu, Huang. Study supervision: Wu, Huang.

Supplemental Information

Videos

Video 1. <https://vimeo.com/536418560>.

Video 2. <https://vimeo.com/536418717>.

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