Superior Pulmonary Sulcus (Pancoast) Tumors

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Rudolf A. Hatz

Introduction

Superior pulmonary sulcus, or Pancoast. Tumors extend to the superior thoracic inlet and cause characteristic symptoms and signs, including steady, unrelenting shoulder and arm pain along the distribution of the eighth cervical and first and second thoracic nerve trunks. The severe pain radiates toward the vertebral margin of the scapula and along the ulnar aspect of the upper arm to the elbow and finally to the ulnar surface of the forearm and the small and ring fingers of the hand (Pancoast-Tobias syndrome). This classic syndrome also includes Horner syndrome (ptosis, miosis, and enophthalmos) and weakness and atrophy of the intrinsic muscles of the hand. It was the radiologist Henry Pancoast who associated these typical complaints with an apical chest tumor, naming it *superior sulcus carcinoma*. His initial thought that the tumor was extrapulmonary in origin, arising from the epithelial remnant of the fifth bronchial cleft, was corrected by Tobias, who recognized its origin as bronchopulmonary and explained the specific symptoms according to the tumor's location, not its histopathologic origin. Because the extent of neoplastic involvement of the brachial plexus, parietal pleura, endothoracic fascia, subclavian vessels, vertebral bodies, and first, second, and third ribs varies throughout the course of tumor growth, invading the thoracic inlet, many patients initially are treated for presumed cervical osteoarthritis or bursitis of the shoulder, which often delays the correct diagnosis by 5–10 months.

Most superior sulcus lesions are caused by non–small cell lung carcinoma (NSCLC), most commonly squamous, followed by adenocarcinoma and large cell carcinoma. Small cell carcinomas are rare. The differential diagnosis includes primary thoracic neoplasms such as mesothelioma and hemangiopericytoma, metastatic and hematologic neoplasms, infectious diseases, the cervical rib syndrome, and pulmonary amyloid nodules. Therefore, diagnosis should be facilitated by a detailed preoperative workup to define the histology and ultimately to assess operability. Definitive histology may be obtained by fiberoptic bronchoscopy and percutaneous transthoracic needle biopsy in 95 % of patients. CT and especially MRI studies are best suited for imaging the extent of superior sulcus tumors and defining mediastinal lymph node involvement. MRI is superior to CT in showing tumor extension to the brachial plexus, subclavian vessels, vertebral bodies, and spinal canal and should be obtained in every patient prior to surgical resection.

The indication for surgery principally depends on two variables: (1) the clinical tumor stage, that is, the extent of lymph node involvement at the pN2 and pN3 levels and the incidence of distant metastatic spread, and (2) the technical resectability of the tumor. The former can be determined by including brain imaging, positron emission tomography, and bone scan in the preoperative workup. Tumor spread to the N2 level is best visualized by mediastinoscopy. Proper and careful preoperative evaluation of N2 and N3 lymph nodes is underscored by the fact that 5-year survival in patients with pN2 and pN3 involvement is less than 10 %. Technical resectability, meaning the achievement of an R0 resection with negative margins on histopathologic examination, is

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difficult to accomplish because of the special anatomic complexity of the thoracic inlet and the narrow margin between achieving a complete resection and the possible long-term major disability of the patient as a consequence of overassessing resectability. In many cases, because patients initially present with extensive local tumor growth, neoadjuvant chemotherapy is needed to induce tumor regression to enable local R0 resection and minimize the risk of disability following surgery.

Because most Pancoast tumors are the result of NSCLC, it is now common opinion that wedge resection of the lung is not acceptable and a lobectomy should be performed to guarantee optimal long-term survival for the patient. If complete resection cannot be achieved, resection should not be attempted, because survival does not differ between incomplete resection and no resection. Therefore, in view of the reportedly high rate of incomplete resections, a thorough understanding of the different surgical approaches to these locally complex tumors is necessary. The approach varies depending on where the tumor infiltrates the apex based on preoperative MRI: anteriorly from the sternum to the middle scalene muscle or posteriorly from the middle scalene muscle to the posterior aspect of the brachial plexus and vertebral bodies. More anteriorly infiltrating tumors may extend to the subclavian vein, anterior and middle scalene muscles, subclavian artery, phrenic nerve, and trunks of the brachial plexus. Tumors located posteriorly approach the posterior scalene muscle, posterior scapular artery, brachial plexus, long thoracic nerve, spinal accessory nerves, sympathetic chain, stellate ganglion, neural foramina, and vertebral bodies. The classic Pancoast tumor very frequently infiltrates the first rib with possible extension to the second and third ribs.

Whichever surgical approach is selected, sufficient access is mandatory, not only to resect the tumor completely at the thoracic inlet but also to allow lobectomy and radical mediastinal lymphadenectomy to be performed during the same procedure. The following figures depict two approaches and their modifications: the classic posterior approach, first reported by Shaw and Paulson, and the modified anterior transcervical thoracic, or transmanubrial osteomuscular sparing, approach.

Posterior (Shaw-Paulson) Approach

Figure 46.1

The patient is intubated with a double-lumen tube and placed in a lateral decubitus position. The sterile field is prepared to include the upper arm and scapula, with skin preparation reaching from the base of the skull down to the iliac crest and past the spinal processes posteriorly and the midline anteriorly, encompassing the neck, manubrial notch, and sternum. The lower arm should be draped to just above the elbow to permit a gentle pull of the upper arm by the second assistant to elevate the scapula, if necessary. The surgeon stands at the patient's back, the first assistant across the table, and the second assistant cephalad to the surgeon. The patient's arm is placed on a sterilely draped padded arm rest. A long posterior thoracotomy is made starting midway between the spinal processes and the posterior aspect of the scapula, and is extended forward in a gentle arch 2–3 cm below the inferior angle of the scapula until the anterior border of the latissimus dorsi muscle is reached. As a modification, according to Tatsamura, this incision may be continued upward to above the nipple level to access more anteriorly located structures and to permit adequate mediastinal lymphadenectomy

Figure 46.1

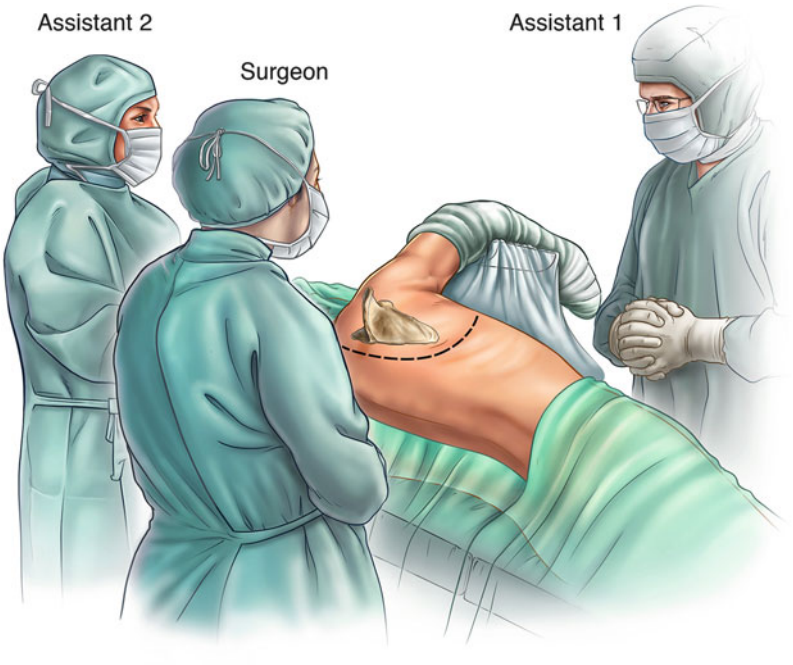


Figure 46.2

Anteriorly, the latissimus dorsi and the fascia posterior to the anterior serratus muscle are incised along their posterior edges (**a**). Posteriorly, the trapezius muscle is divided along the full length of the incision, then the lesser and greater rhomboid muscles and the levator muscle of the scapula. Care should be taken not to injure the dorsal scapular nerve and satellite scapular artery at this point. The anterior serratus muscle fibers along the fifth intercostal space are divided, and the pleural cavity is entered after the intercostal muscles are divided (**b**). This approach allows the assessment of resectability and better visualization of the upper lobe. Next, a retractor is placed to displace the scapula upward and forward and the sixth rib downward. At this point, the brachial plexus, axillary artery, and middle and posterior scalene muscles are visible

Figure 46.2

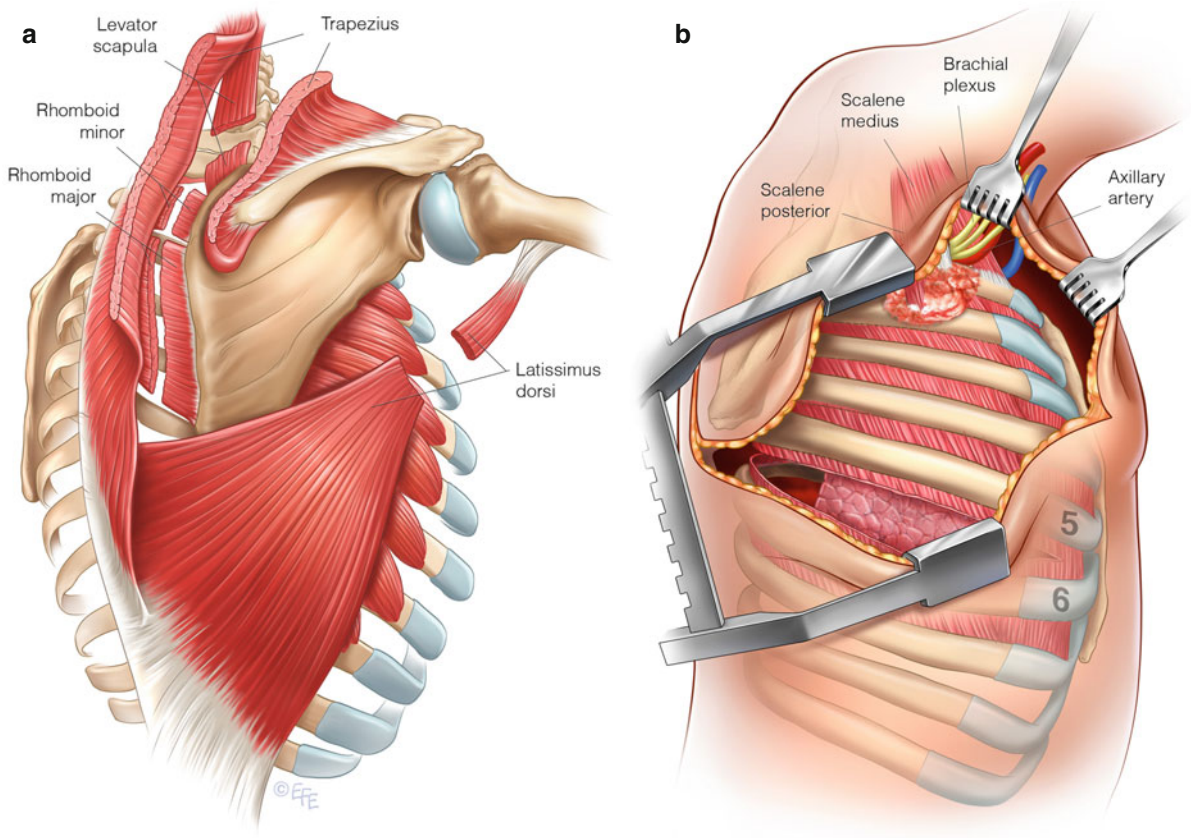

a
Levator scapula
Trapezius
Rhomboid minor
Rhomboid major
Latissimus dorsi
b
Brachial plexus
Scalene medius
Scalene posterior
Axillary artery
5
6

Figure 46.3

(**a**, **b**) Simultaneous bimanual palpation at this point helps determine the extent of tumor infiltration to the chest wall and into the thoracic inlet. As shown here, the first rib and the cranial portion of the second are infiltrated. It is important that negative resection margins are obtained. Therefore, the intercostal muscles of the second intercostal space are divided close to the third rib or the third rib is included in the resection. With a Brunner rib shear, the second rib is divided first anteriorly and then posteriorly. Intervening intercostal neurovascular pedicles are suture ligated or clipped and then divided. The middle and posterior scalene muscles are transected with cautery, providing access to the posterior angle of the first rib. After the angle of the invaded first rib is dissected to obtain tumor-free margins, the rib is transected with a right angle rib shear. If no further infiltration is present in the brachial plexus, subclavian artery, and vein, the anterior scalene muscle is transected and the first rib divided with a 60°-angle rib shear. When dividing the anterior scalene muscle, care must be taken not to sever the subclavian vein, which runs ventrally to this muscle. This may be avoided by the operator placing a finger between the muscle and vein and transecting the muscle directly at the point of its insertion onto the first rib. The rib should be cut to the level of the costocartilage anteriorly. Following resection including the first and second rib, the segment of chest wall is dropped into the chest cavity and the procedure is completed by lobectomy and mediastinal lymphadenectomy

Figure 46.3

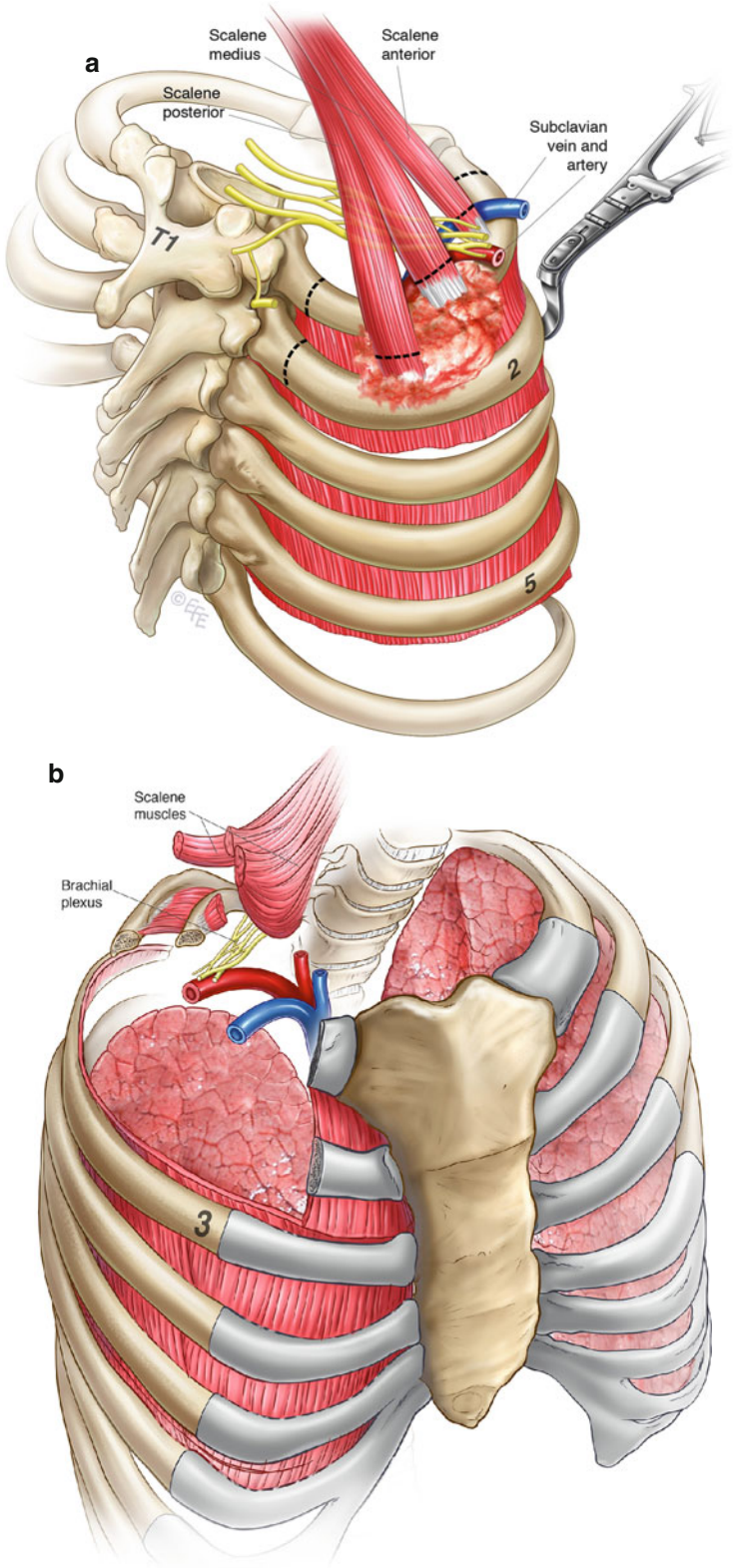
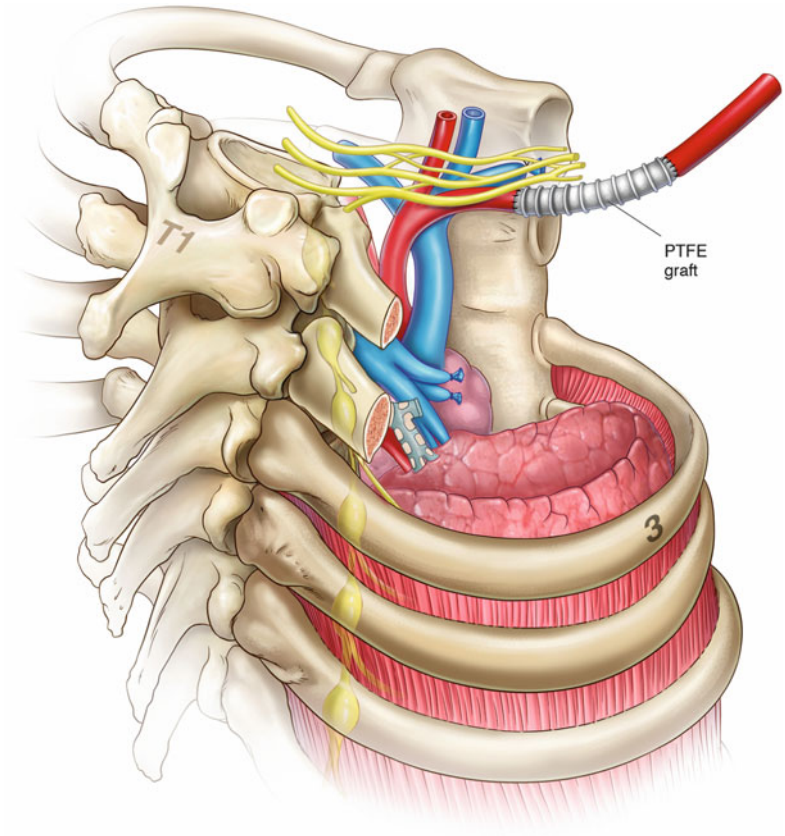

a
Scalene medius
Scalene anterior
Scalene posterior
Subclavian vein and artery
T1
2
5
b
Scalene muscles
Brachial plexus
3

Figure 46.4

If tumor invades the most posterior aspect of the first and second ribs near the transverse ligaments, as may be confirmed intraoperatively by a frozen section of uncalcified periosteum, the transverse process along with the lateral cortex of the vertebrae may be transected with an osteotome. Up to one quarter of the vertebral body may be removed without affecting stability. The sympathetic chain is then divided above and below the tumor mass, and the stellate ganglion is resected. Most commonly, tumor invasion of the brachial plexus is limited to the first thoracic and eighth cervical nerve roots. In these cases, the lower trunk of the brachial plexus should be divided. To prevent cerebrospinal fluid leakage, the nerve roots should be secured with a ligature before being transected at the intervertebral foramen. If the subclavian vein and artery are infiltrated by tumor, special operative measures are indicated. The vein may simply be sutured and ligated; the artery should be cross-clamped. Following adequate systemic heparinization, revascularization by end-to-end anastomosis or interposition of a ring-fortified polytetrafluoroethylene (PTFE) graft (6 or 8 mm) should be performed, as shown here. However, such procedures may be very hazardous if attempted through a posterior approach; as a safer alternative, such maneuvers should be performed through an additional anterior approach (see Fig. 46.5)

Figure 46.4

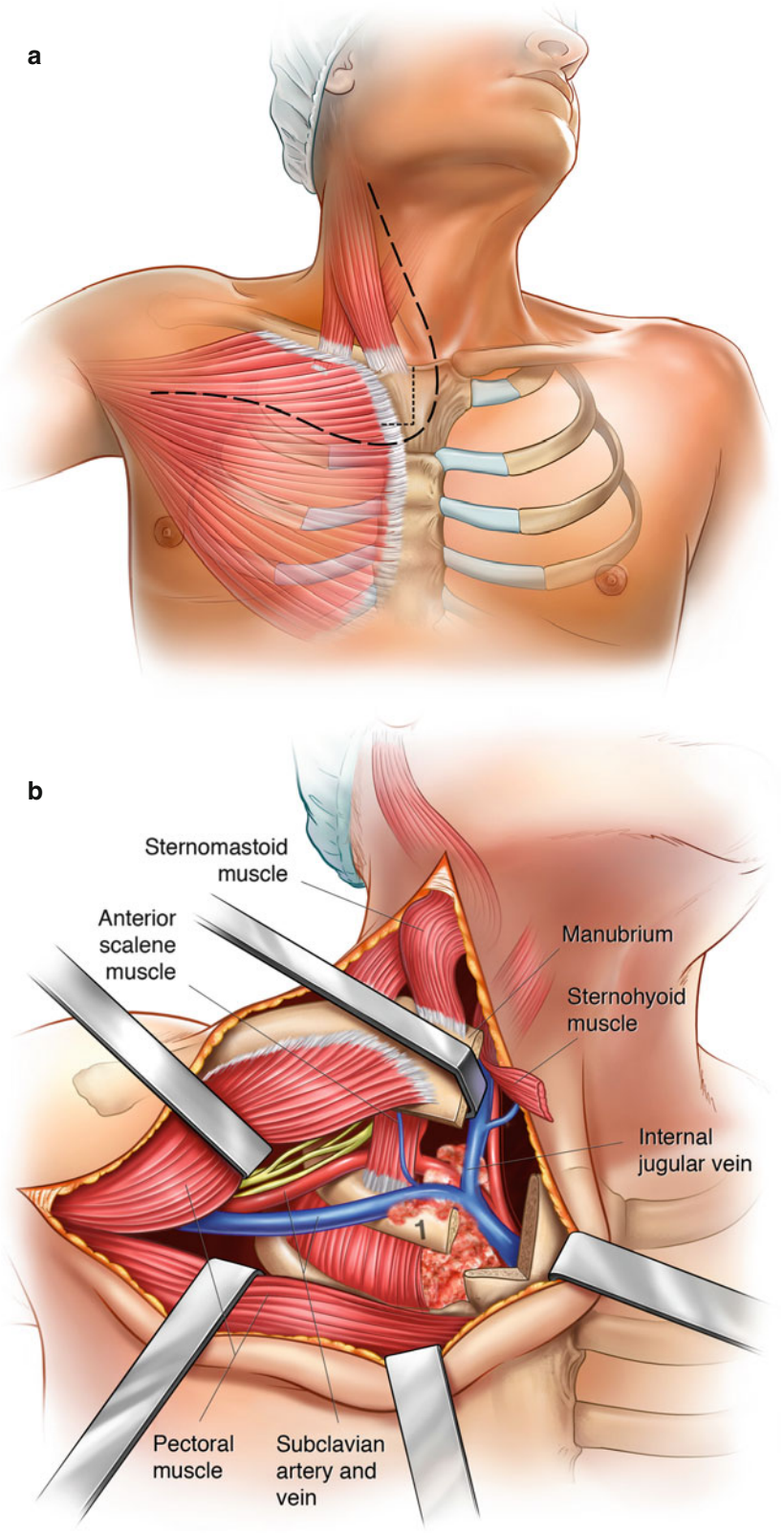


The Transmanubrial Osteomuscular Sparing (Grunewald-Spaggiari) Approach

Figure 46.5

(**a**, **b**) An L-shaped incision is made starting along the anterior border of the sternocleidomastoid muscle to the jugulum, passing down midline to the manubrium and then laterally into the second intercostal space. This may be done with the patient in a lateral decubitus position by rotating the operating table toward the patient's back and placing the patient's sterilely draped arm on a pad fixed to the table behind the patient, or, if a posterior (Shaw-Paulson) approach is not necessary, in a supine position with the neck hyperextended and the head rotated accordingly. The sternohyoid muscle is transected, and the greater pectoral muscle between the clavicular and sternocostal parts in the anterior chest wall is split. The manubrium is divided down the middle in a reverse L-shape with a sternal saw. Division of the first costal cartilage allows the clavicle and ipsilateral half of the manubrium to be retracted. After the costoclavicular ligament is cut along the clavicle, the subclavian muscle is exposed and transected at the posterior surface of the clavicle. Retraction of the myocutaneous flap fully exposes the neck, thoracic inlet, and upper part of the chest wall. Accordingly, the jugular veins may be dissected. For proper exposure of the subclavian artery, the anterior scalene muscle is divided either on its insertion on the scalene tubercle on the first rib or in tumor-free margins, with careful assessment of the phrenic nerve to prevent unnecessary division. The subclavian artery may then be dealt with according to its spatial relationship to the infiltrating tumor. If the tumor rests against the wall of the subclavian artery, the artery can be freed following a subadventitial plane. If invasion is present, resection is indicated and revascularization facilitated by end-to-end anastomosis or interposition of a ring-enforced PTFE graft (6 or 8 mm)

Figure 46.5


a
b
Sternomastoid muscle
Anterior scalene muscle
Manubrium
Sternohyoid muscle
Internal jugular vein
1
Pectoral muscle
Subclavian artery and vein

Conclusion

Complete resection of superior sulcus tumors remains challenging because of their location with respect to the posterior and anterior compartments of the thoracic inlet and to their varying degrees of infiltration into the delicate structures located at this site. Therefore, new treatment paradigms have evolved to improve the thoroughness of resection. One of the most recent is the introduction of induction chemoradiotherapy followed by radical surgical resection by one of the surgical approaches discussed earlier or, more frequently, a combination of both. The largest multimodality study to date (Southwestern Oncology Group [SWOG] 9416) reported an induction regimen of concurrent chemoradiotherapy (two cycles of induction chemotherapy [cisplatin, 50 mg^{-2}, with etoposide, 50 mg^{-2}] and 45 Gy of radiotherapy) followed by surgery and postoperative boost chemotherapy with two cycles of cisplatin/etoposide. Only patients with N0/N1 tumors were included. A complete or near-complete response was achieved in 61 %, and the completeness of resection was 94 %. Actuarial 5-year survival for all patients was 44 %, 54 % after a complete response. Based on these and other data, the modern treatment standard for sulcus superior tumors has become induction chemoradiotherapy followed by radical surgical resection.

Which surgical approach the surgeon selects depends on the invasiveness and localization of the tumor with respect to the thoracic inlet. We believe a combination of both allows safe control and resection of thoracic outlet structures, pulmonary hilar elements, and the posterior thoracic wall in most cases. Several groups have shown that more extensive malignant involvement of vertebral bodies may be resected successfully with a combined anterior and posterior approach in conjunction with single- and multilevel partial and hemivertebrectomy and laminectomy and posterior stabilization.

Prognostic factors for tumor recurrence are completeness of resection and the T and N status of the tumor. In every case, lobectomy should be performed, followed by coverage of the bronchial stump. Several centers do not advise resection if N2 involvement is present. The Union for International Cancer Control (UICC) classifies ipsilateral supraclavicular lymph node disease as N3. However, in Pancoast tumors, positive ipsilateral supraclavicular lymph nodes demonstrate a better prognosis than those in other lung tumors, because these nodes seem to represent local extension of the tumor to the nodes and not distant metastases.

Surgical morbidity ranges from 7 to 38 %, with surgical mortality around 5–10 % reported in the literature. Surgical complications include Horner syndrome, spinal fluid leakage, nerve deficits, hemothorax, chylothorax, and paralysis of the diaphragm with prolonged ventilatory support.

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