Technique of Pleurectomy and Decortication

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Pleurectomy-decortication (P/D) was first popularized in the mid 1950s as a surgical method for treating entrapped lung that developed as a complication of tuberculous empyema. P/D evolved as a treatment for a variety of lung pathologies including other infectious empyemas, effusive metastatic disease, and pleural metastases. As diffuse malignant pleural mesothelioma (MPM) came to prominence in 1960, when Wagner and coworkers described MPM in asbestos mine workers from South Africa,[1] P/D was one method adapted and utilized for treating MPM. A rare disease with an incidence of just under 1 per 100,000 in the United States, cases of MPM have increased since the 1970s with an estimated 2000 to 3000 new diagnoses in America each year.[2] Today, MPM remains a lethal cancer without consensus regarding optimal staging and treatment. In particular, the role of surgical resection in MPM and, specifically, the choice of extrapleural pneumonectomy (EPP) versus P/D, remains highly controversial.

Definitions

P/D is an attempt to remove all gross disease without removing the underlying lung and involves resection of the parietal pleura, visceral pleura, the pericardium, and, in roughly 50% of patients, the diaphragm. Macroscopic evidence of involvement of the pericardium requires resection and reconstruction; however, diaphragmatic disease can often be successfully stripped from the surface of the diaphragm without formal resection and reconstruction.

Indications and Contraindications

MPM was universally thought to be fatal in the era before effective systemic therapy. Surgery was primarily used for diagnostic or palliative purposes. In 1976, Butchart and colleagues reported their experience with EPP for MPM and documented durable long-term survival, yet a 33% operative mortality.[3] Refinements in patient selection and perioperative care substantially decreased mortality rates. Contemporary series report mortality as low as 3.4%[4] and 5.2%,[5] illustrating that high-volume centers could perform EPP safely. Nonetheless, the high mortality and morbidity associated with EPP, and the well-known complications of pneumonectomy, led some surgeons

toward P/D. The mortality of P/D is 1.0% to 4.0% and to date there is no evidence showing superiority of EPP over P/D.[6] Regardless of technique, certain fundamentals hold true: surgery is a key component in the treatment of MPM and achieving a macroscopic complete resection is the goal. Indications supporting P/D over EPP can be related to either patient or tumor characteristics. In patients with insufficient cardiopulmonary reserve for pneumonectomy, a postoperative predicted forced expiratory volume in one second or a diffusing capacity of the lung for carbon monoxide of less than 40%, or a left ventricular ejection fraction of less than 45%, P/D is clearly indicated. In early stage disease, confined to the parietal pleura (Butchart I, IMIG T1a) or confined to parietal and visceral pleura without involvement of underlying lung parenchyma (IMIG T1b), P/D provides clearance of disease without the additional morbidity or mortality of a pneumonectomy.

In patients with confluent sheets of tumor involving the entire lung and obliterating the pleural space, P/D is unfeasible and EPP should be considered. Computed tomographic (CT) scans may provide preoperative evidence of this level of tumor involvement, but often this decision is made intraoperatively. MPM is a disease where a true R0 resection is impossible and surgical therapy provides removal of gross tumor as a foundation for adjuvant therapy. With this perspective, P/D may limit adjuvant therapy by limiting the dose of radiation used in the postoperative hemithorax. However, with newer methods of radiation administration such as intensity modulated radiation therapy and encouraging results with systemic chemotherapy, residual lung parenchyma left after P/D may not alter adjuvant therapy as much as previously thought and may protect the patient from the morbidity of a pneumonectomy.

Preoperative Evaluation

Imaging of the chest and upper abdomen with CT is mandatory. If chest wall or neurovascular invasion is suspected, MRI may be helpful in preoperative planning. Positron emission tomography/CT is done to screen for distant metastatic disease and the standard uptake value can be used to predict the presence of N2 lymphatic spread.[7] Although N2 disease does impart a worse prognosis in MPM, it should not be used as an absolute criteria denying surgical resection. Therefore, there is no absolute indication for preoperative mediastinoscopy. Ventilation/perfusion scans are helpful in cases where pulmonary function tests (PFTs) are questionable or the extent of pleural disease significantly alters the patient's ability to perform for the PFTs and a more accurate assessment of lung function is needed. Patients with postoperative predicted values of greater than 40% are considered acceptable for either EPP or P/D.

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Operative Technique
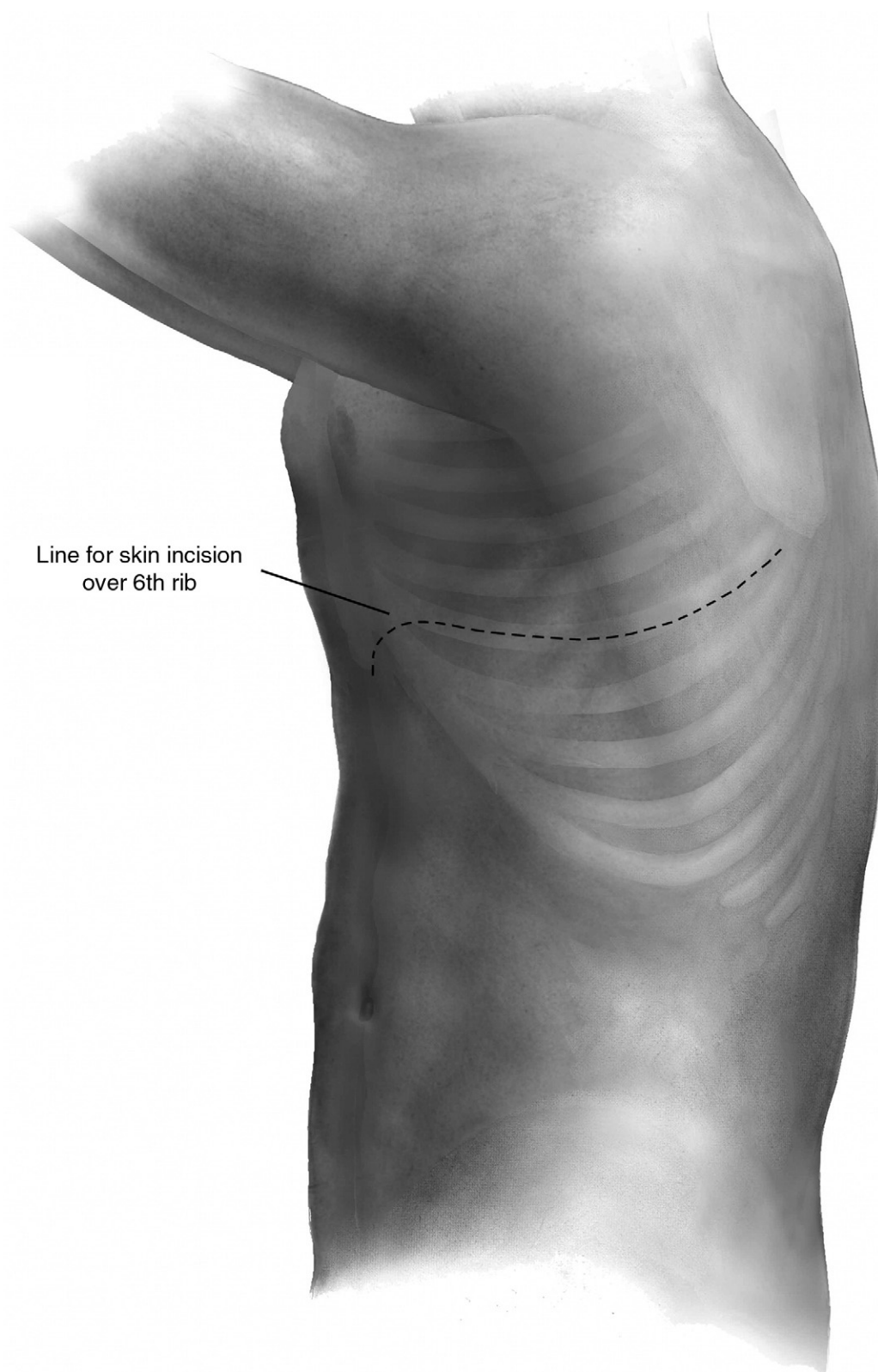

Line for skin incision
over 6th rib

Figure 1 Positioning and approach: Following the induction of general anesthesia, a double-lumen endotracheal tube is used to facilitate single-lung ventilation. An arterial line and central venous line are also used to aid in arterial and venous pressure monitoring as blood loss is often significant. The patient is placed in the lateral decubitus position. An extended posterolateral thoracotomy incision, extending down toward the costal margin over the 10th rib and posteriorly beyond the tip of the scapula, is made. At first, a more limited incision, such as a standard posterolateral thoracotomy incision, can be used to start the procedure. After intrathoracic assessment of respectability, the incision can be extended anteriorly as mentioned above.
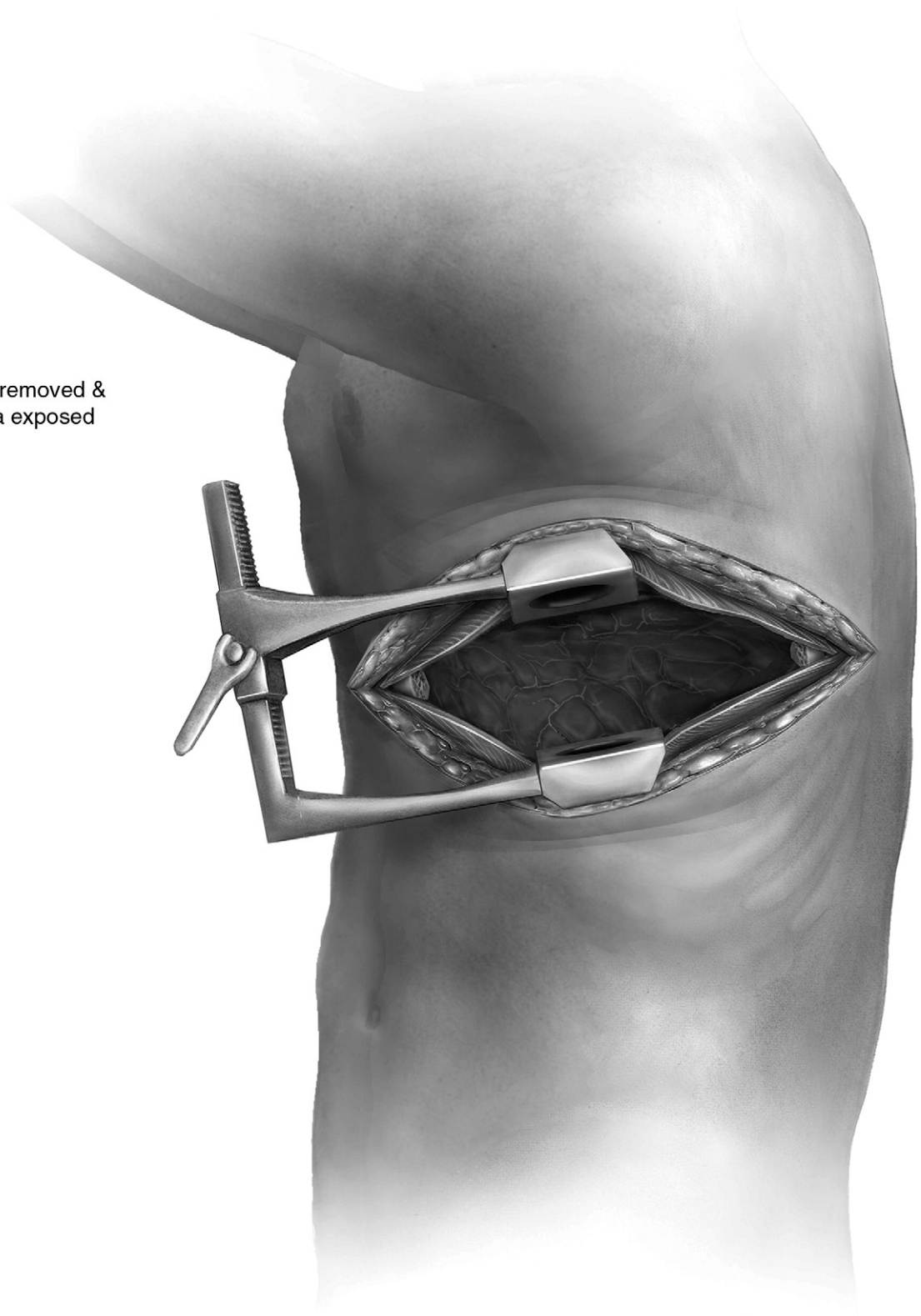
6th rib removed &
pleura exposed

Figure 2 Exposure: The incision is brought down over the sixth rib and the periosteum is elevated off the rib superiorly and inferiorly. A periosteal elevator is used to separate the rib for the surrounding soft tissue. A Bethune rib cutter is used to divide the rib anteriorly and posteriorly and the rib is removed. Dissection between the endothoracic fascia and the parietal pleura is begun. Allis clamps placed on the endothoracic fascia elevating the fascia away from the pleura allows for easier dissection in the plane between the 2 layers. Once an area large enough for a finger is created, blunt dissection of the tumor laden pleura can be easily undertaken with a finger.
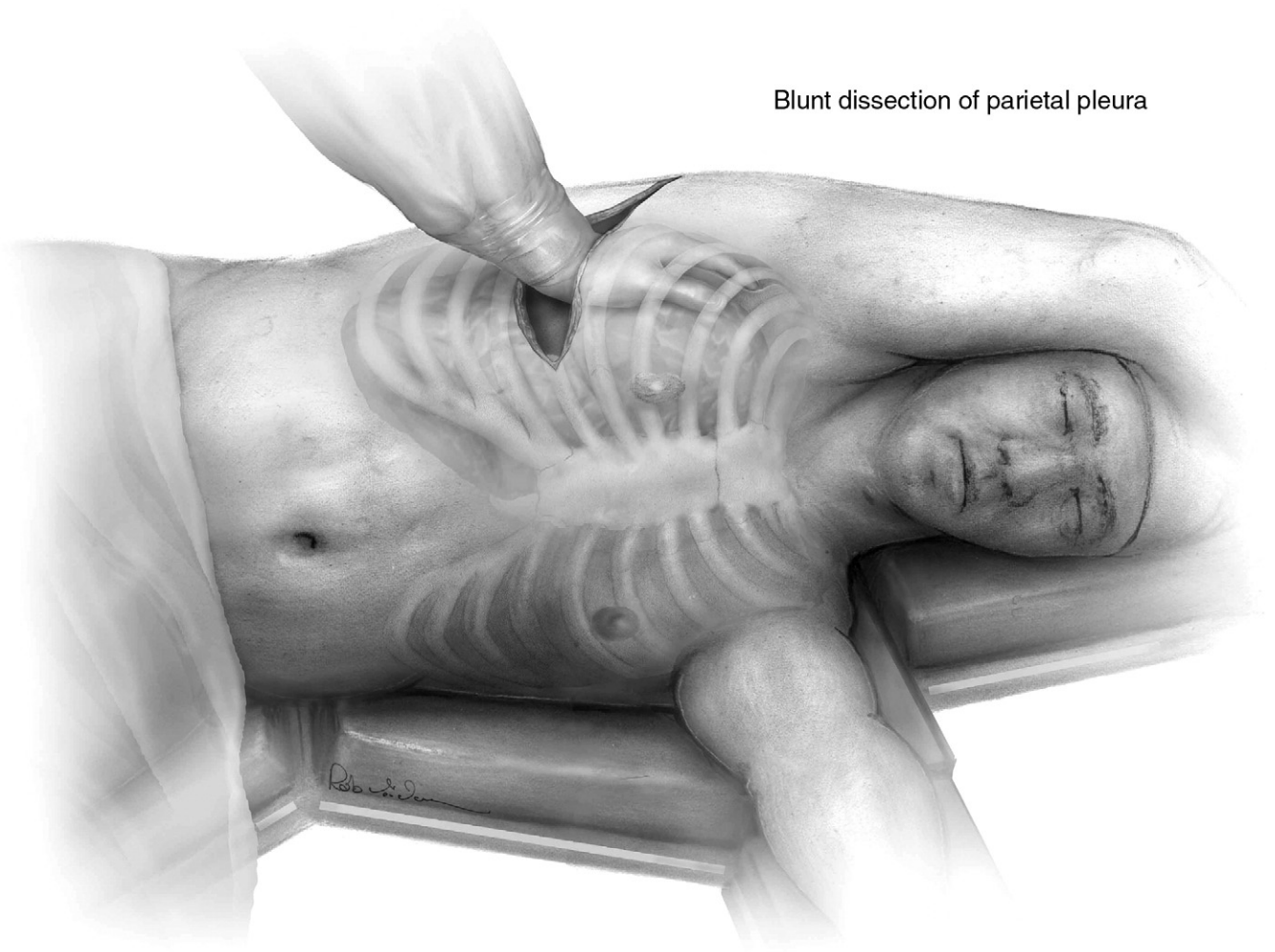
Blunt dissection of parietal pleura

Figure 3 Dissection of the extrapleural plane: The plane is then developed in a cephalad direction toward the apex from the posterolateral direction. Both blunt and sharp dissection are used with sharp dissection reserved mainly for areas of dense adhesions. The apex is usually relatively free of tumor compared with the diaphragmatic surface, and dissection in this direction first will make exposure and inferior dissection easier. The placement of 2 Finnechetto retractors, 1 anteriorly and the other posteriorly, greatly enhances the visualization of the thoracic cavity. As the dissection moves anteriorly, injury to the internal mammary vessels must be avoided. Blunt dissection with sponge sticks can effectively separate the pleura from the anterior chest wall close to the mammary vessels but sharp dissection is recommended once the vessels are encountered. As the area of dissection increases, previous areas of dissection are packed with laparotomy pads for hemostasis.
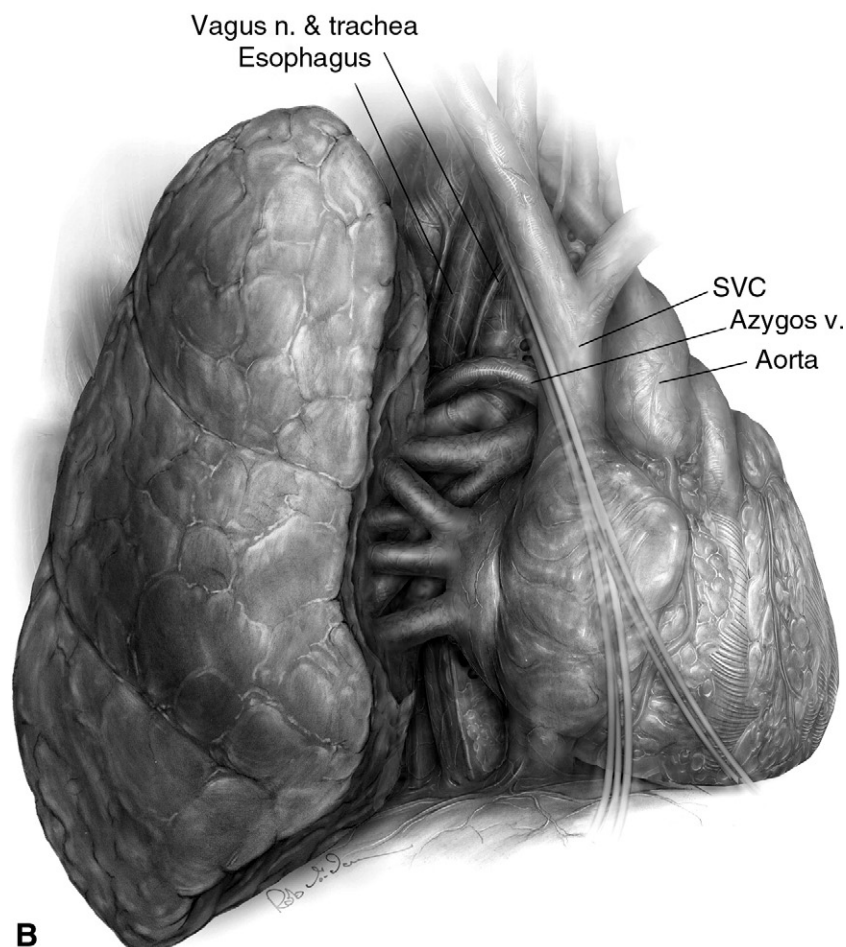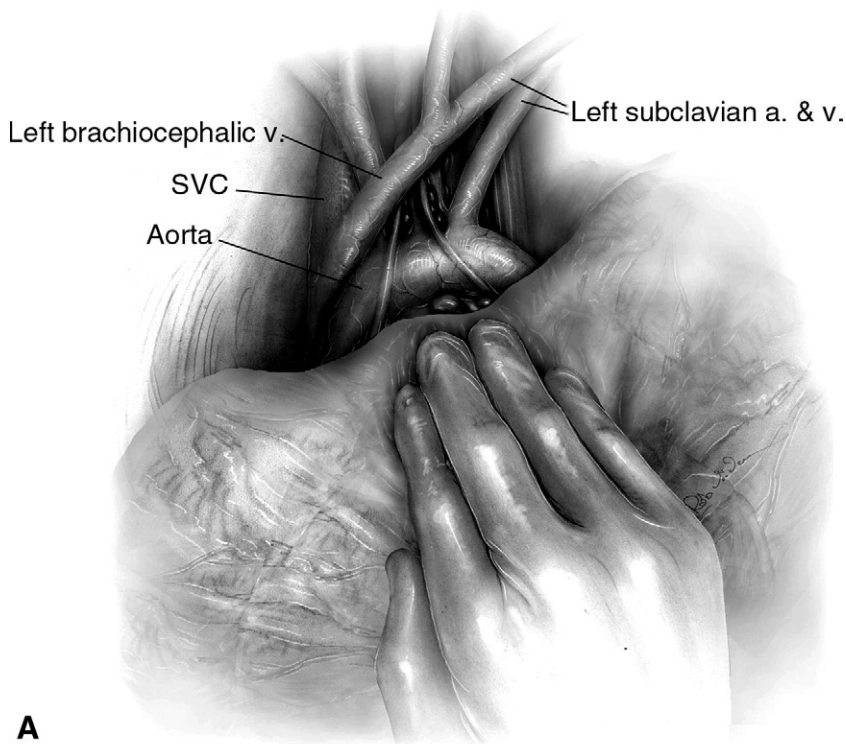
Figure 4 Dissecting the apex: The subclavian vessels lie at the apex of the thoracic cavity. As the dissection progresses toward the apex, great care must be used in dissection around the subclavian vessels. As the dissection proceeds toward the mediastinum, the azygous vein and superior vena cava are approached carefully. Once the upper portion of the lung is completely mobilized from the chest wall, the superior and posterior hilar structures are well exposed. (A) The aorta and arch vessels must be identified and carefully dissected. Injury to the phrenic nerve and recurrent laryngeal nerve must also be avoided. (B) After the right upper lobe and right mainstem bronchus are exposed, dissection of the esophagus is begun. A nasogastric tube is helpful in palpating and identifying the esophagus. The superior vena cava is gently dissected off the specimen and the dissection continues to the posterior aspect of the pericardium. The vagus and phrenic nerves again are identified and protected. a. = artery; n. = nerve; SVC = superior vena cava; v. = vein.
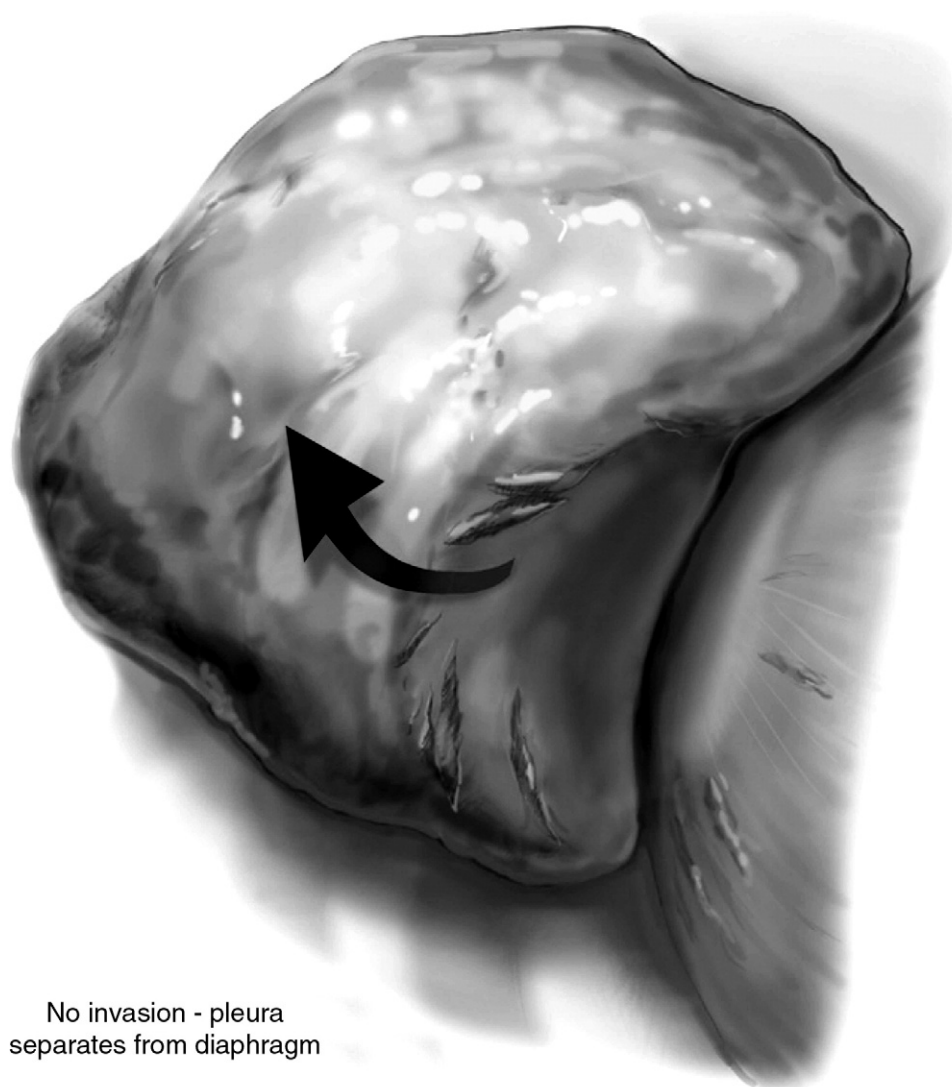
No invasion - pleura
separates from diaphragm

Figure 5 Elevation of the parietal pleura off the diaphragm: The burden of tumor at the level of the diaphragm will determine if resection is necessary. If the parietal pleura peels easily off the diaphragm, the diaphragm can remain intact. (Reprinted with permission from Wolf AS, Daniel J, Sugarbaker DJ: Surgical techniques for multimodality treatment of malignant pleural mesothelioma: extraplerual pneumonectomy and pleurectomy/decortication. Semin Thorac Cardiovasc Surg 21:132-148, 2009.)

Invasion - diaphragm
avulsed radially

Figure 6 If there is substantial diaphragmatic invasion, the diaphragm is resected bluntly by avulsing off the chest wall. The diaphragmatic muscle attachments to the chest wall are manually separated with a fingertip as done with EPP. Care is taken to dissect the peritoneum off the undersurface of the diaphragm muscle. The diaphragm is grasped in an Allis clamp or Babcock clamp and retracted upward. The peritoneum is gently dissected off the undersurface with a sponge stick. At the esophageal hiatus the inferior vena cava must be identified and great care used in the dissection of the diaphragm off the inferior vena cava. (Reprinted with permission from Wolf AS, Daniel J, Sugarbaker DJ: Surgical techniques for multimodality treatment of malignant pleural mesothelioma: extraplerual pneumonectomy and pleurectomy/decortication. Semin Thorac Cardiovasc Surg 21:132-148, 2009.)
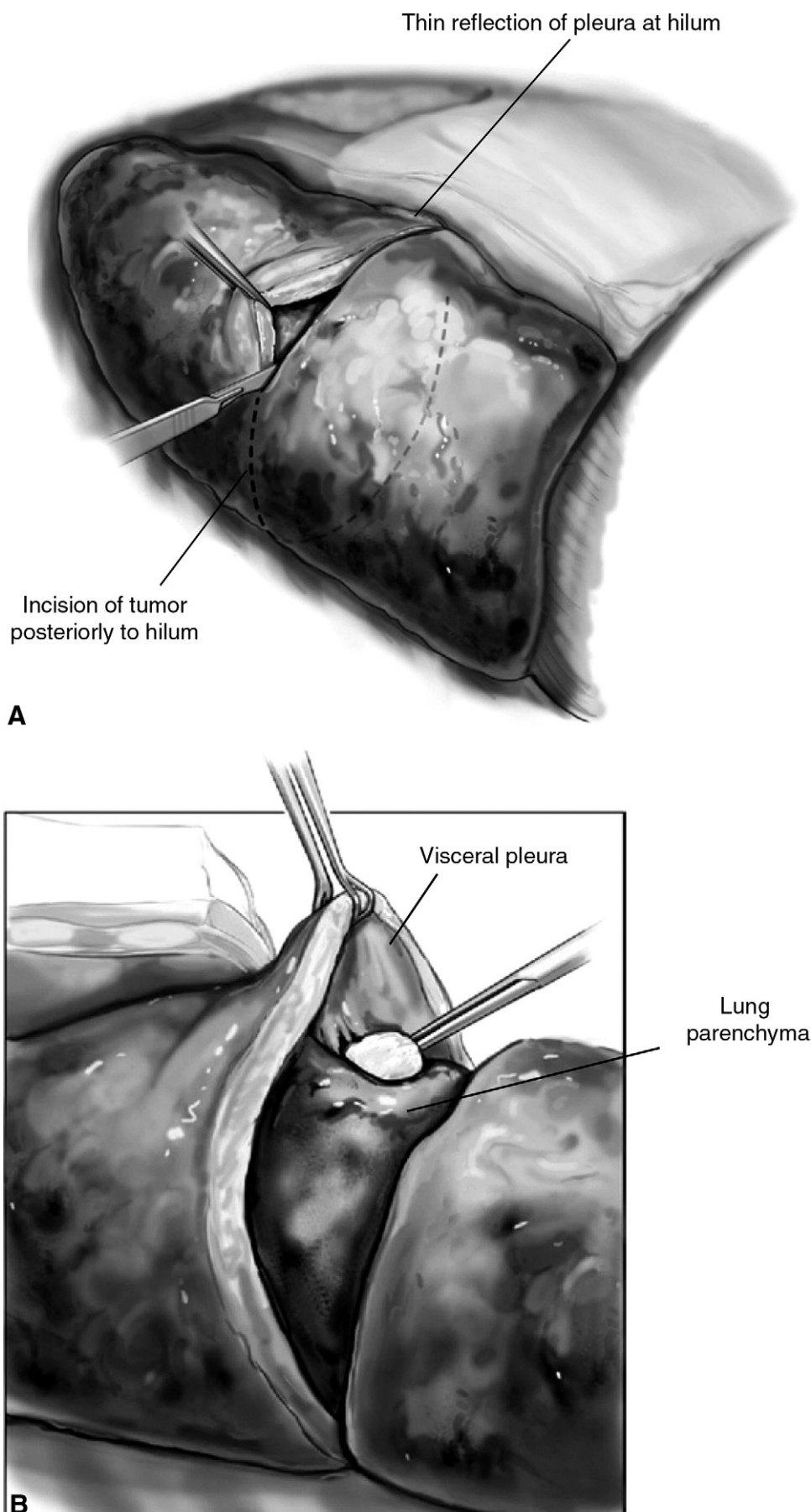
Thin reflection of pleura at hilum

Figure 7 Decortication: Once the parietal pleura has been freed in all areas, attention is shifted toward separating the visceral pleura from the underlying lung parenchyma. (A) Using a scalpel, an incision is made in the tumor overlying the area of the sixth rib and brought down to healthy lung tissue but avoiding injury to the parenchyma. A plane is created between the visceral pleura, which is adherent to the tumor, and the lung parenchyma with gentle blunt dissection with a peanut sponge (B). The plane of dissection is brought superiorly over the apex and then inferiorly. (Reprinted with permission from Wolf AS, Daniel J, Sugarbaker DJ: Surgical techniques for multimodality treatment of malignant pleural mesothelioma: extrapleural pneumonectomy and pleurectomy/decortication. Semin Thorac Cardiovasc Surg 21:132-148, 2009.)
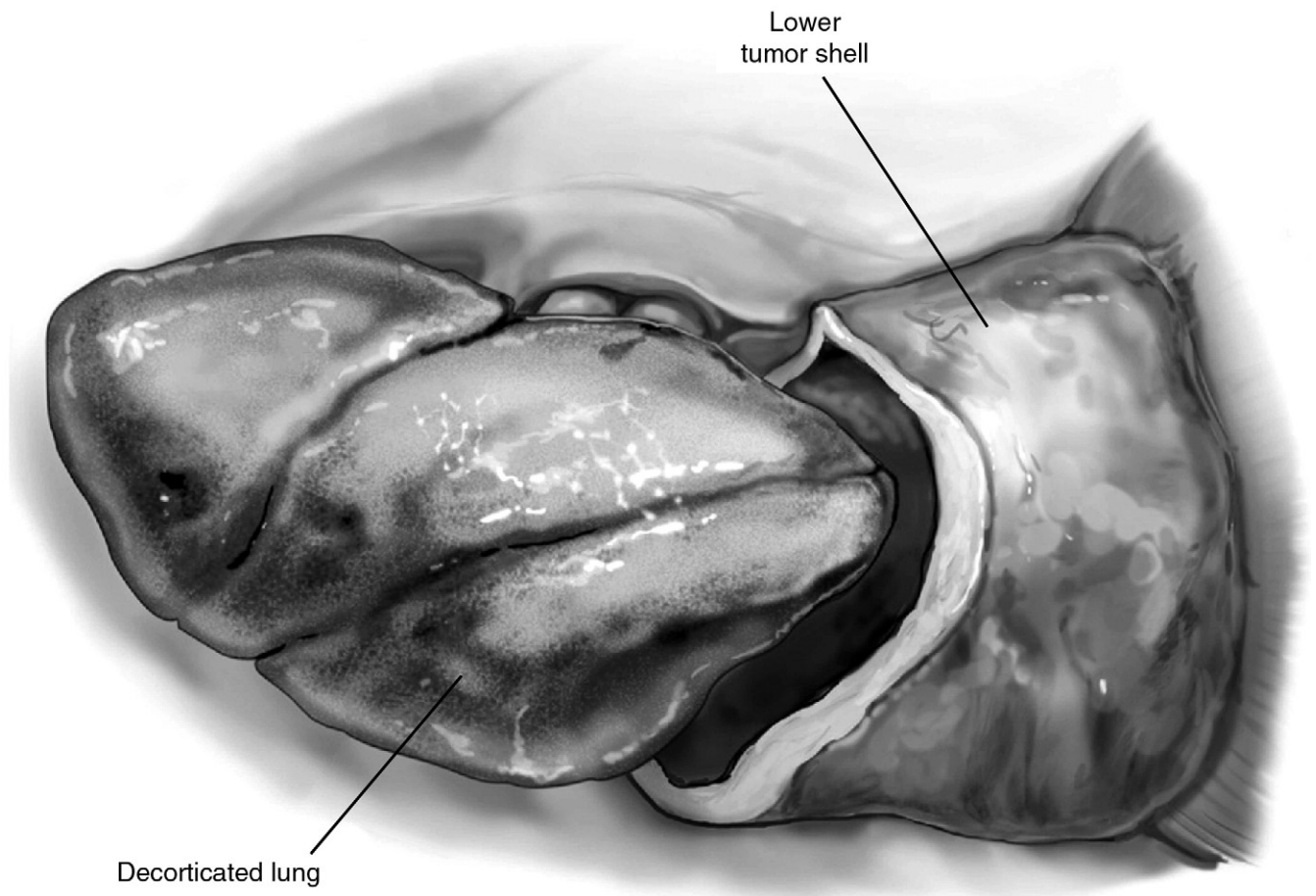
Incision of tumor posteriorly to hilum

A

Visceral pleura

Lung parenchyma

B

Lower
tumor shell

Decorticated lung

Figure 8 The incision in the pleura can be extended anteriorly toward the hilum. The lung parenchyma is then pulled out of the tumor/pleural cap. (Reprinted with permission from Wolf AS, Daniel J, Sugarbaker DJ: Surgical techniques for multimodality treatment of malignant pleural mesothelioma: extraplerual pneumonectomy and pleurectomy/decortication. Semin Thorac Cardiovasc Surg 21:132-148, 2009.)
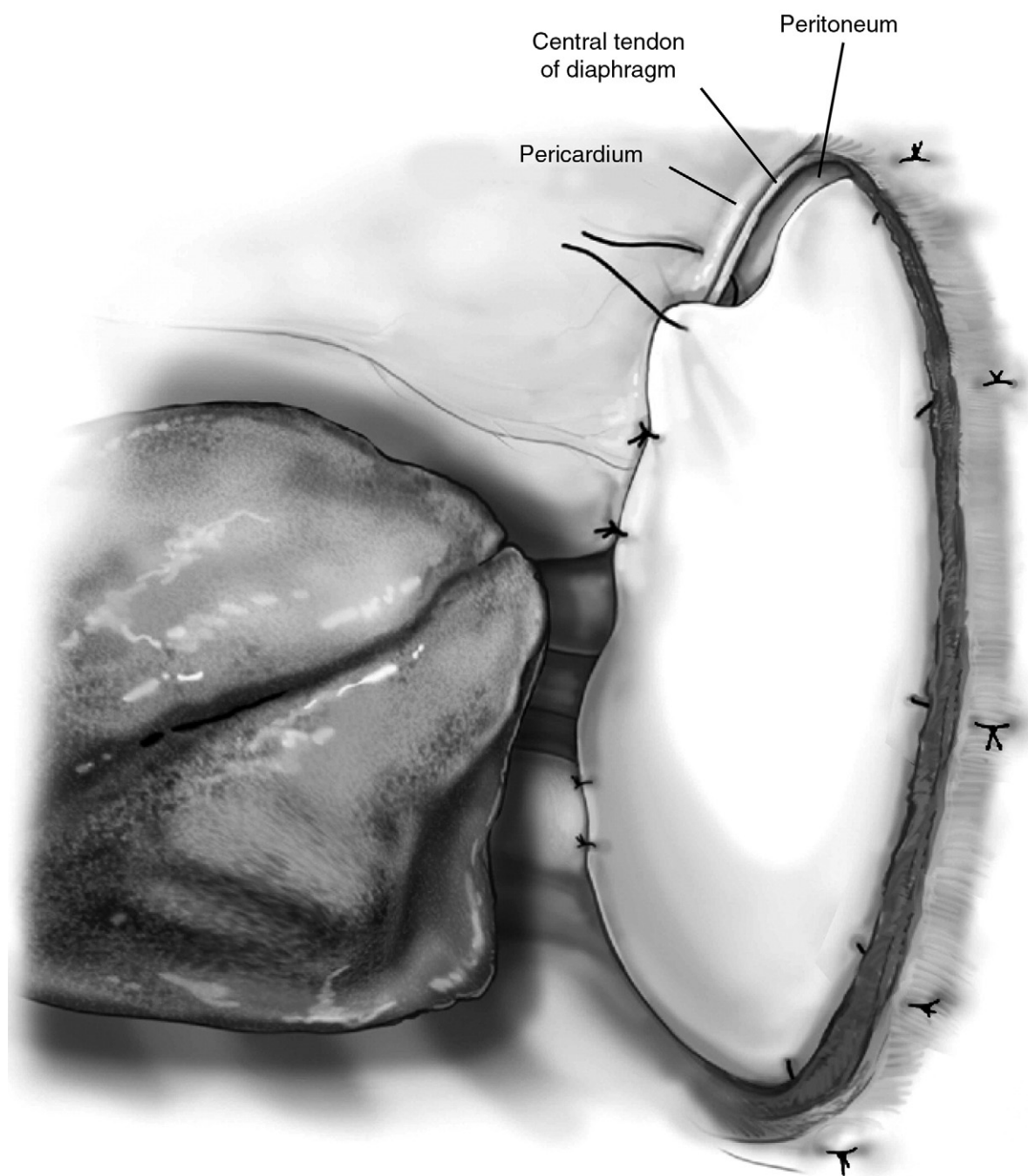
Figure 9 Repair of the diaphragm: After resection of the diaphragm, care must be taken to repair the diaphragm by attaching the diaphragmatic patch to the pericardium. In addition, the patch must be pulled taut to protect the residual lung from loss of domain and atelectasis caused by upward motion of the abdominal organs. On the right, a double-layer Dexon mesh (Covidien, Norwalk, CT) is adequate. On the left, 2-mm-thickness Gore-Tex (W.L. Gore & Associates, Inc, Flagstaff, AZ) is used because a thicker, nonabsorbable material is needed to prevent herniation of abdominal contents. The prosthesis is secured laterally by sutures placed around the ribs through the soft tissue of the chest wall. (Reprinted with permission from Wolf AS, Daniel J, Sugarbaker DJ: Surgical techniques for multimodality treatment of malignant pleural mesothelioma: extraplerual pneumonectomy and pleurectomy/decortication. Semin Thorac Cardiovasc Surg 21:132-148, 2009.)
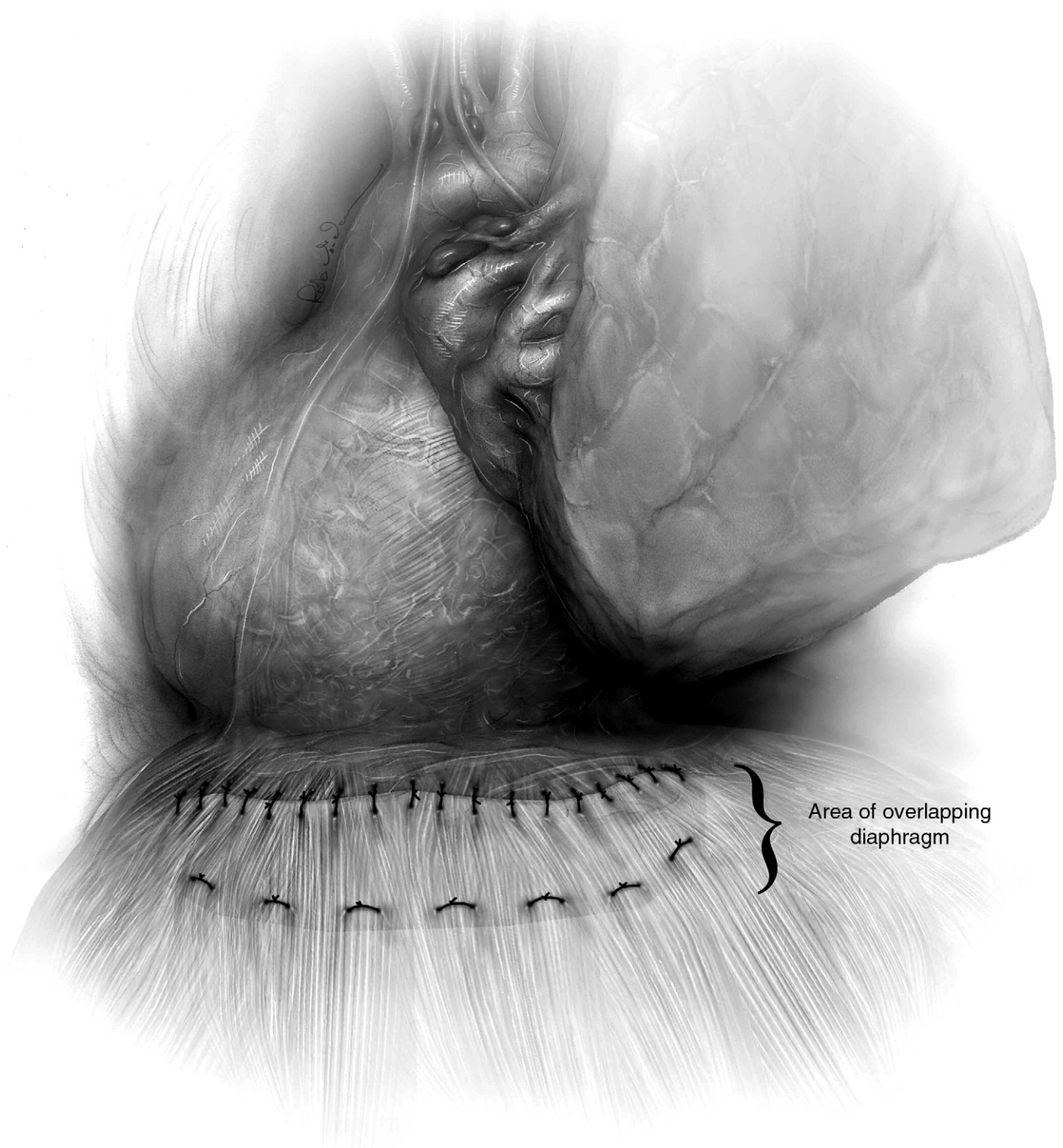
Figure 10 If the diaphragm is largely intact, it can be closed primarily by plication. Nonabsorbable sutures, such as 0-Prolene sutures, are used to imbricate the diaphragm to itself. If the pericardium has been resected, Dexon mesh is used for reconstruction.
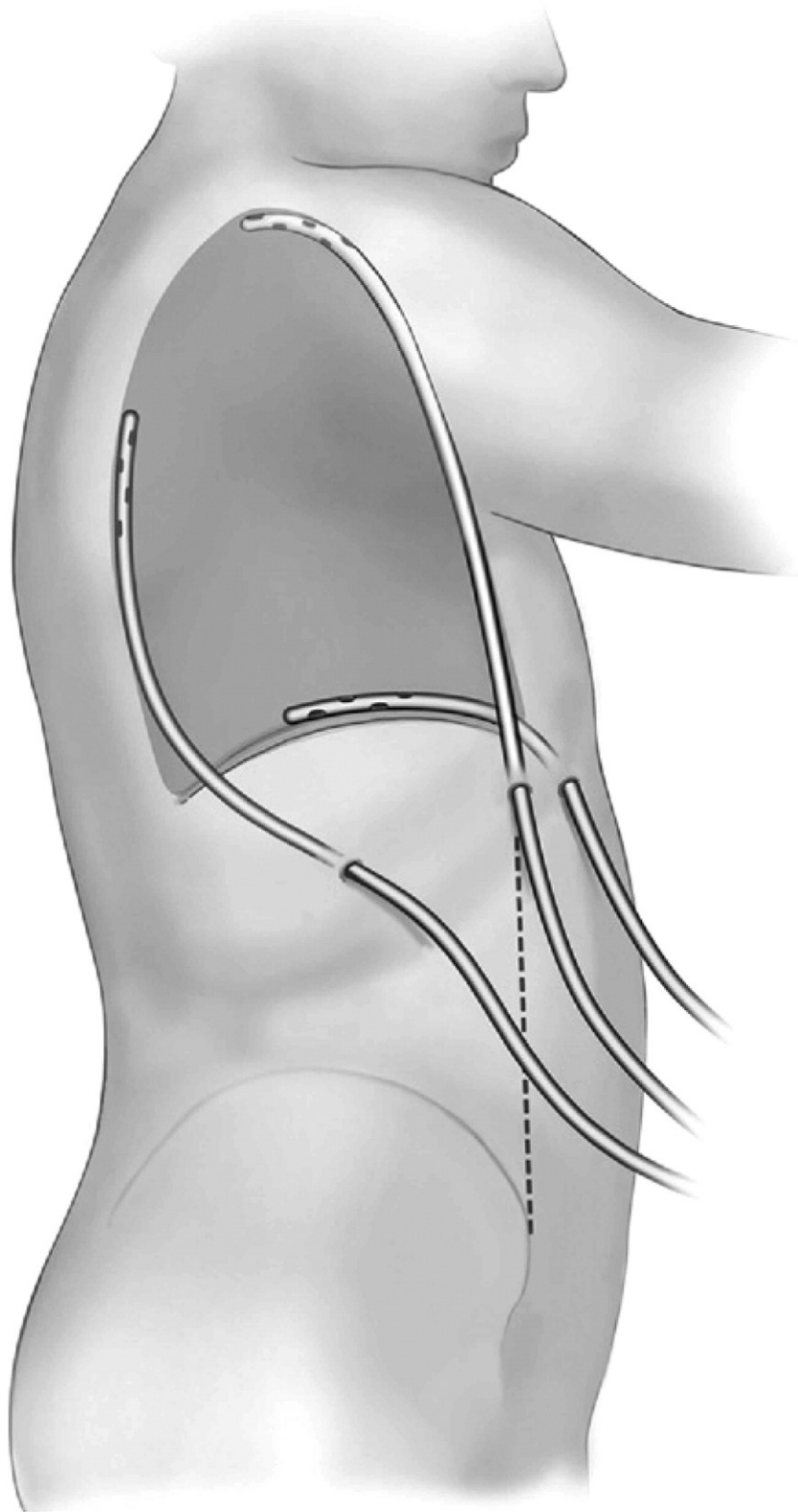
Figure 11 Attention is now turned to obtaining hemostasis. An argon beam coagulator is helpful in controlling diffuse chest wall bleeding. Another, often more effective device, is the Aquamantys System bipolar coagulator (Salient Surgical Technologies, Portsmouth, NH). Three 28-French chest tubes are then placed: 1 anterior, 1 posterior, and 1 right-angled. The right-angled tube is placed from the most anterior incision so it rests along the diaphragm toward the most dependent area of the chest. Evacuation of blood and control of air leaks can be accomplished and full expansion of the lung is expected. Air leaks tend to seal within 72 hours if the lung is fully expanded. (Reprinted with permission from Wolf AS, Daniel J, Sugarbaker DJ: Surgical techniques for multimodality treatment of malignant pleural mesothelioma: extraplerual pneumonectomy and pleurectomy/decortication. Semin Thorac Cardiovasc Surg 21:132-148, 2009.)

Results

P/D is a safe procedure with mortality limited to approximately 1 to 4%. The most common postoperative complication is prolonged air leak (air leak lasting more than 7 days), which occurs in upward of 10% of cases. Continued chest tube drainage is sufficient in a majority of cases as the air leaks will seal over time. Pleurodesis is reserved for air leaks that fail simple chest tube drainage and good expansion of the lung parenchyma is observed on chest x-ray. Rarely, continued air leaks are managed with a BD Bard-Parker Heimlich Valve (BD, Franklin Lakes, NJ). In these cases, all but 1 chest tube is removed after sequential clamping and serial chest x-rays document adequate lung expansion. Median survival time ranges from 9 to 20 months. The literature shows that surgery alone is insufficient therapy and results in rapid relapse of disease.[8] Suboptimal cytoreduction is believed to be the cause. Irrespective of procedure, EPP or P/D, a complete R0 resection is impossible because microscopic disease is invariably left behind. Therefore, most treatment regimens have focused on multimodality approaches combining a surgical procedure for cytoreduction with chemotherapy and radiation in a multimodality setting. The majority of recent studies have described either EPP or P/D in combination with neoadjuvant or adjuvant chemotherapy, intrathoracic chemotherapy, adjuvant external beam radiotherapy or intensity modulated radiation therapy, intraoperative radiotherapy, or brachytherapy. Due to small sample sizes and comparatively heterogeneous groups, a consensus on treatment strategies and conclusions regarding optimal therapy remain lacking.

In the largest study to date, Flores and coworkers analyzed 663 MPM patients from 3 different institutions and compared overall 5-year survival. A total of 385 patients were identified who underwent EPP and 278 patients who underwent P/D. Of these patients, a statistically significant number of early stage (I-II) patients favored P/D, whereas a statistically significant number of patients favored EPP due to younger age and having received multimodality therapy. In univariate analysis, P/D was associated with a significantly better median survival than EPP ($P < 0.001$). However, in a multivariate analysis by a Cox proportional hazard model that controlled for histology, stage, gender, and multimodality therapy, EPP had only a modestly higher hazard ratio of 1.4 when compared with P/D. Of note, operative mortality was 7% in the EPP group and 4% in the P/D group with a higher proportion of EPP patients experiencing serious respiratory complications (10%) compared with the P/D cohort (6.4%).[6] Until a randomized controlled trial is completed, current therapy remains controversial with the choice of P/D or EPP directed by a combination of disease characteristics, patient characteristics, and surgeon discretion.

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