McCraw and Arnold's Atlas of Muscle and Musculocutaneous Flaps

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INTRATHORACIC MUSCLE FLAPS

INTRODUCTION

The use of an intrathoracic muscle transposition to correct a bronchopleural fistula was first described in the early Twentieth Century by Abrashanoff (1911) and later by Kanavel (1921). Since that time intrathoracic muscle flaps have been used to reinforce bronchial stump closures, obliterate empyema cavities, and bolster problem suture lines of the trachea, esophagus, heart, and great vessels. When compared to open and infected wounds of the extremity and trunk, the same problems within the chest cavity can be precipitous and life-threatening. Because of the unusual nature of these procedures, the special technical considerations are reviewed in this chapter.

GENERAL CONSIDERATIONS

The most commonly used muscles in these types of procedures have been the serratus anterior, the pectoralis major, the latissimus dorsi, and the rectus abdominis muscles. The first three muscles are always transposed into the intrathoracic position through a separate thoracotomy to improve their arc of rotation. This access is gained by removing five to ten centimeters of one or more ribs. The pectoralis major muscle flap is usually introduced through the second rib bed in the midaxillary line. The latissimus dorsi muscle flap is passed into the chest through a second rib thoracotomy in the posterior axillary line. The serratus anterior muscle is introduced at approximately the same level in the midaxillary line. All of these "second" thoracotomies are placed near the axis of rotation of the muscle flap so the dominant vasculature will not tether a "straight shot" into the thorax. The most direct passage for the rectus abdominis muscle flap is through the anterior leaf of the diaphram, which is a harmless maneuver. The superiorly based rectus abdominis muscle flap is a distant choice for intrathoracic problems because of its remote location and its inability to reach the upper thorax.

CHOICE OF MUSCLE FLAPS

When the intrathoracic problem is isolated, such as a "clean" reinforcement of a tracheal suture line or a bronchial stump closure, a small, malleable, and accessible muscle is ideal. The fourth and fifth intercostal muscles do produce a major chest wall donor defect, but they do fill these criteria and have excellent suture retention capabilities. The rectus abdominis muscle flap is unusual to consider because of its remoteness. One of the three major extrathoracic muscle flaps — latissimus, pectoralis, or serratus — is usually chosen, even for isolated defects, because of its reliability and accessibility. The location of the existing thoracotomy is the most important factor in this choice of muscle flap since it is easier to use a muscle which lies nearest to the existing thoracotomy.

A previous standard posterolateral thoracotomy is the most common reason for not using the latissimus muscle flap. The previously divided latissimus muscle will survive in situ on its respective proximal and distal blood supplies, but the total muscle will not survive elevation as a proximally based muscle flap. The remaining "stump" of the latissimus can be used to provide bulk even though its full length is not serviceable as a standard muscle flap. Although the latissimus muscle is criticized because of its bulk, the anterior portion of the muscle can be skeletonized on the dominant vascular bundle to provide a long, thin flap. More often, its bulk is an advantage.

The pectoralis major muscle is usually not injured during a standard thoracotomy, and this is a common reason to choose it instead of the latissimus muscle flap. It is a large muscle, and the mobilization requires a significant amount of dissection. The accessibility of the pectoralis muscle flap to the upper chest and mediastinum is its major commending feature. The donor site deformity of this reliable flap is its most detractive feature. When transposed to the intrathoracic position, the large pectoralis muscle occupies a considerable space. This is of great benefit when obliterating an upper lobe empyema cavity, wrapping the aortic arch, reinforcing the anterior surface of the heart, or repairing a fistula between the trachea and the great vessels. Like the latissimus muscle flap, the pectoralis major muscle can be skeletonized along the distribution of its dominant vasculature. Both of these muscles are known for their poor suture retention capabilities.

The serratus anterior muscle is ideally located for intrathoracic transposition. It is relatively thin and quite malleable. Its dual proximal blood supply is consistent and durable. The muscle can be transposed comfortably around the mediastinal structures, including the carina, the esophagus, and the trachea. The serratus muscle is usually available since it is seldom transected in the standard thoracotomy. It is our first choice for reinforcement of bronchial stumps, tracheal closures, and other hilar structures.

The rectus abdominis muscle can be used when the previously described muscles have already been used or are absent for some other reason. Other muscles have been utilized as "free" microvascular transfers inside the chest in the rare circumstance in which the latissimus, pectoralis, serratus, and rectus abdominis muscles are not available.

CLINICAL SITUATIONS

Bronchopleural fistula

Bronchopleural fistula with empyema is a dreaded but fortunately an uncommon complication following lobectomy or pneumonectomy. It is even more problematic when previous radiation therapy has been employed. Radiation therapy alone with "cavitation" of the pulmonary parenchyma can also be a cause of empyema.

The first step in wound management is to control the empyema cavity by removing the appropriate number of ribs in a dependent drainage area. This extensive exposure not only allows the cavity to drain but also gives complete access to the infected chest cavity itself for wound care. Irrigation and dressing changes over a variable period of time (days to months) may be necessary before a surgically "clean" wound can be obtained. Ideally it is desirable to wait until the wound is clean before an extrathoracic muscle is transposed into the area of the leak either to plug the leak or to reinforce a direct secondary closure. Once the extrathoracic muscle is transposed over the leaking bronchus, it is simply dressed with an occlusive dressing. The thoracic "window" provides access for pleural drainage and further dressing changes. The dressing is usually changed every twenty-four to forty-eight hours or until the muscle has become firmly "stuck" and sealed the bronchial leak. Once the bronchopleural fistula is under control, consideration can be given to the closure of the chest wall itself. This is usually done by instilling an antibiotic solution and closing the skin directly. Occasionally a thoracoplasty may be necessary to collapse the stiffened chest wall. The authors personally prefer the Clagett procedure, which is a direct skin closure over the antibiotic-filled chest cavity. Before this closure can be successful, the empyema cavity must be controlled, and the bronchopleural fistula must be sealed by the muscle flap closure.

Threatened bronchopleural fistula

When a patient has undergone radiation therapy for a malignancy and a so-called "completion pneumonectomy" is indicated, it is helpful to reinforce the bronchial stump closure with a muscle flap transposition. In a clean wound without an empyema it is reasonable to transpose the muscle over the bronchus and to close the thorax directly as in any other pneumonectomy. If there is any question we would tend to dress the thoracic cavity with an occlusive dressing and close it only when the wound is surgically "clean" and the bronchial stump closure has been secured by a healed muscle flap. This tentative approach is taken in view of the relative ischemia of radiated bronchial stumps and the possible sequelae of a bronchial leak.

Empyema

Occasionally a small tuberculous empyema may be present in the upper lobe region and occupy only a small percentage of the overall thorax. In this situation decortication procedures may not allow the lung to expand adequately and obliterate the thoracic space. It is possible to transpose either the pectoralis major or the latissimus dorsi to obliterate such a small space. It is impossible to fill the entire hemithorax with the extrathoracic muscles since their mass does not nearly approximate the volume of the normal hemithorax.

Reinforcement of suture lines of the heart and great vessels

The pectoralis major muscle has been the most commonly used muscle in this particular situation because of its accessibility. If the suture line in the heart or great vessels is somewhat precarious because of previous irradiation or active infection, it seems reasonable to reinforce these closures with a well-vascularized muscle flap.

Esophageal repair

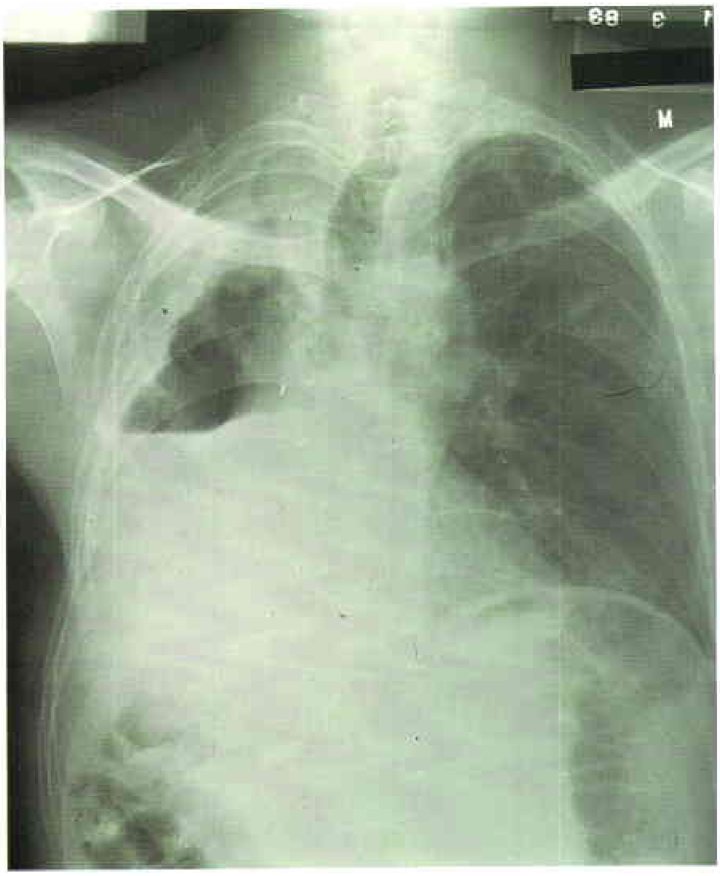
Complicated esophageal repairs are known to be associated with disastrous complications related to failures of wound healing. If it is necessary to mobilize the esophagus extensively so a direct esophageal repair can be accomplished, it seems reasonable to reinforce this repair with transposed, healthy muscle. A muscle flap does not harm the esophageal motility, and it can prevent a suture line leak and a possibly fatal mediastinitis in this single layer closure.

SUMMARY

Intrathoracic infections, which eventually result in a residual pleural space and a bronchopleural fistula, have been consistent and dreaded complications of pulmonary surgery. Intrathoracic infections and irradiation in association with cardiovascular reconstructive procedures have been equally perplexing. Treatment of these life-threatening infections has included antibiotic irrigations, pulmonary resections, and extensive thoracoplasty. All of these methods have had some success, but failure is usually the result of a persistent pleural space which leads to an empyema and eventual breakdown of the intrathoracic repair.

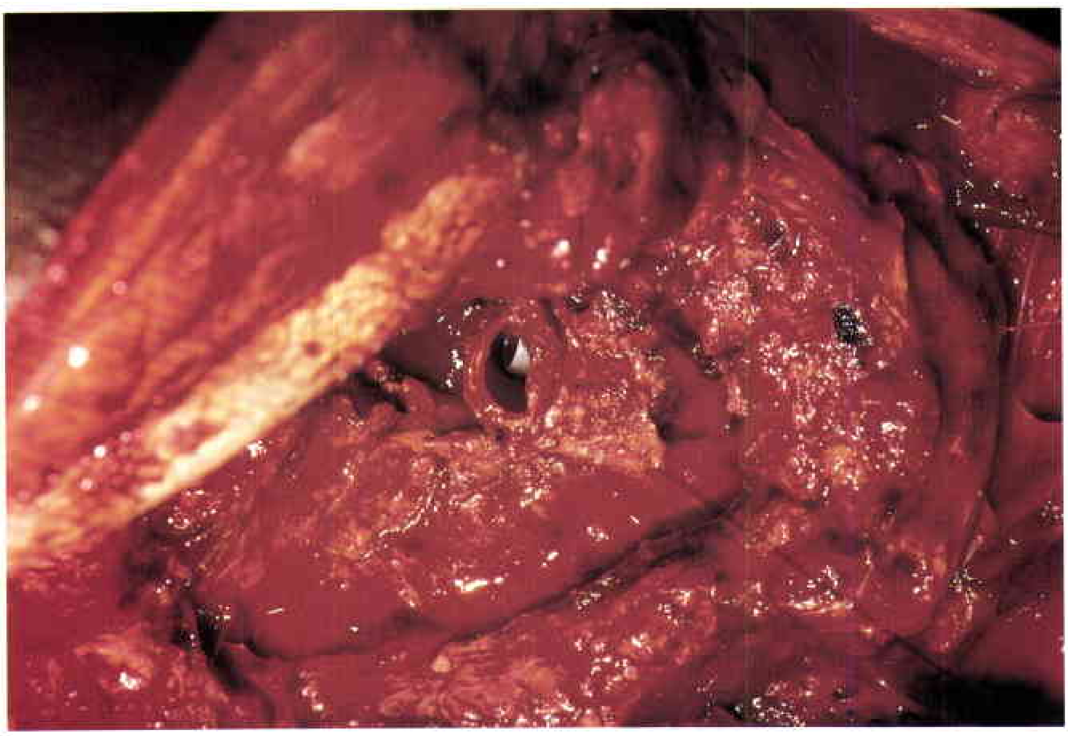
Muscle appears to be the ideal tissue to place in the contaminated or infected intrathoracic wound. The ability of the muscle to combat local contamination has been clearly demonstrated experimentally by Chang and Mathes and confirmed clinically by all of us who have performed muscle flaps under these circumstances. Elsewhere in the body, excellent results have been obtained in reconstructive operations using muscle flaps to close soft tissue defects which are the result of radiation necrosis, trauma, or infection. It follows that an intrathoracic problem with the same origin can be treated similarly.

This is not to say that muscle transpositions are indicated in all patients with chronic intrathoracic infections. Many patients with pleural space infections can be adequately managed with tube thoracostomy drainage, decortication, and systemic antibiotics. Those patients who do not respond to this conservative regimen can often be successfully managed by decortication of the lung, by advancement of the diaphragm, by creation of a pleural tent, or by a limited thoracoplasty. When these methods are unsuccessful or seem likely to fail, an intrathoracic muscle transposition becomes a reasonable alternative. It is certainly applicable in patients with a chronic bronchopleural fistula, especially in association with irradiation or destructive lung disease. In these patients conventional pulmonary resection is difficult because the remaining lung often has restrictive lung disease, which prevents postoperative expansion. Muscle transposition has been most helpful in patients with postpneumonectomy empyema. We feel that intrathoracic transposition of extrathoracic skeletal muscles is an excellent method of treatment for certain persistent, life-threatening intrathoracic infections.



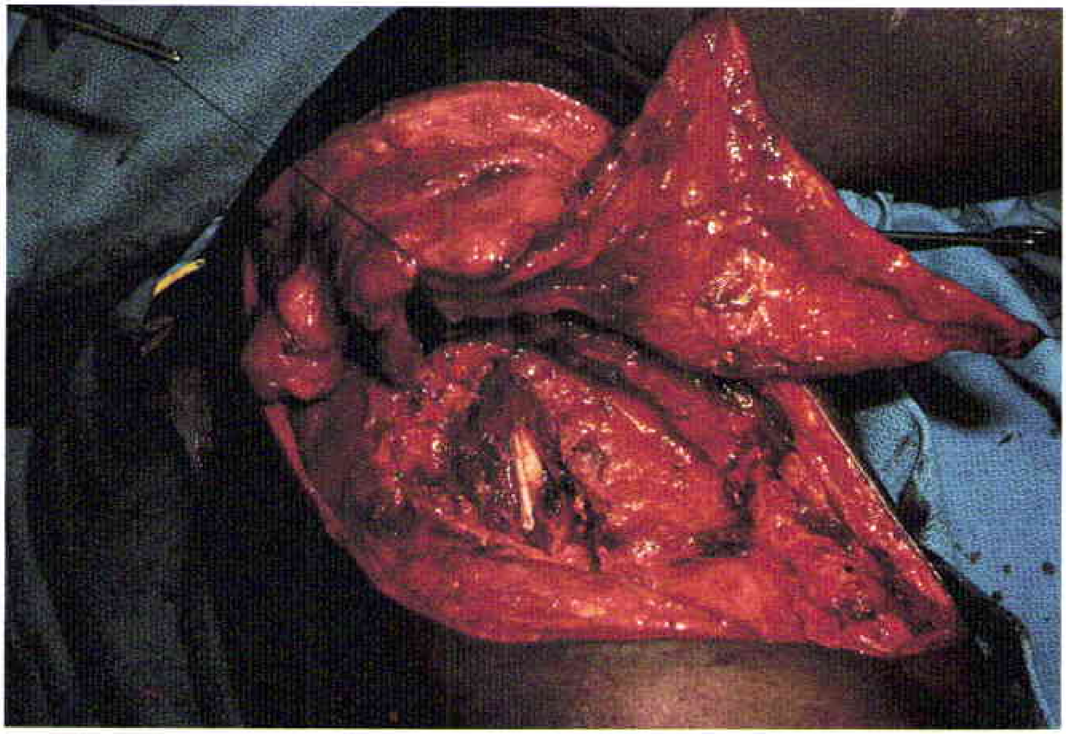
1

Fifty-five-year-old man several months following a right pneumonectomy which was complicated by an empyema and a bronchopleural fistula. A longer than average stump of main stem bronchus was left at the time of the initial resection. (Case of P.G. Arnold)



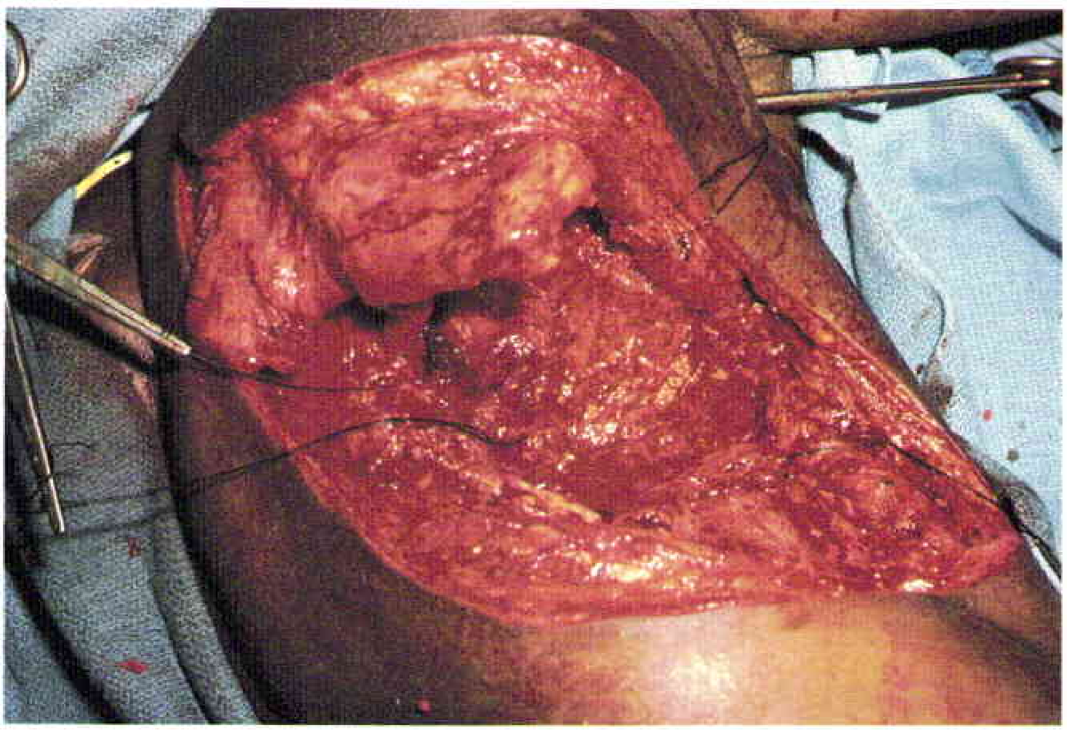
2

The pleural cavity was reopened and the right main stem bronchus was mobilized. Tip of the endotracheal tube can be seen through the cut end of the right main stem bronchus.



3

The serratus anterior muscle is elevated as an "island" muscle flap on the thoraco-dorsal and long thoracic vessels.



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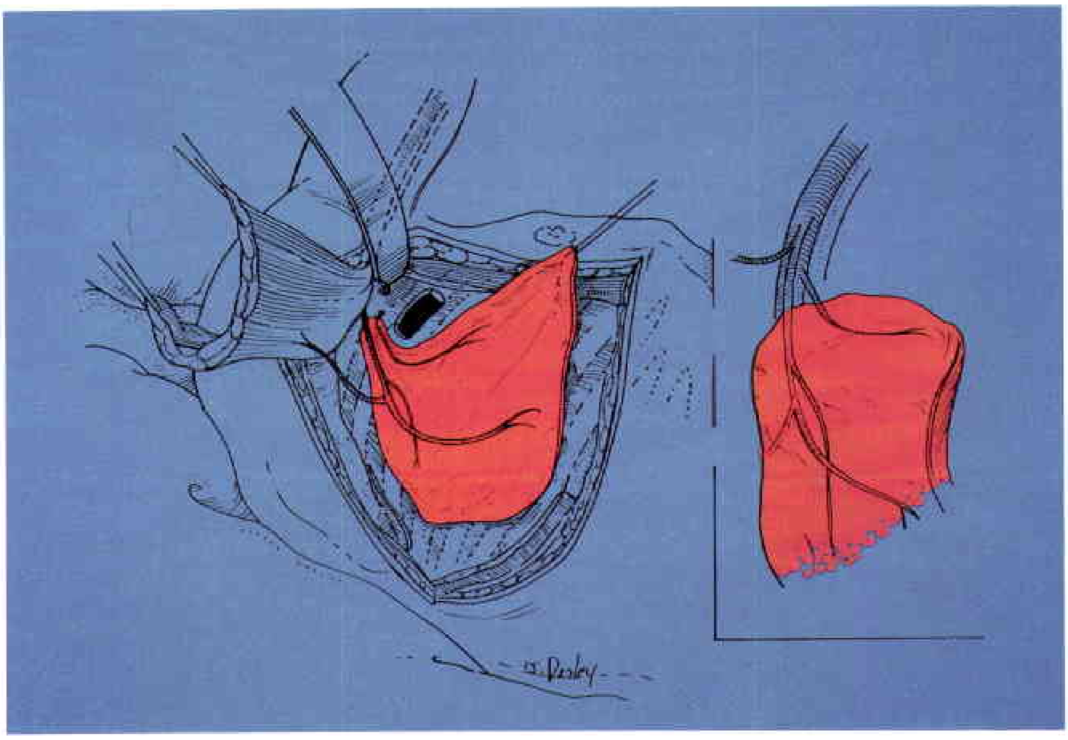
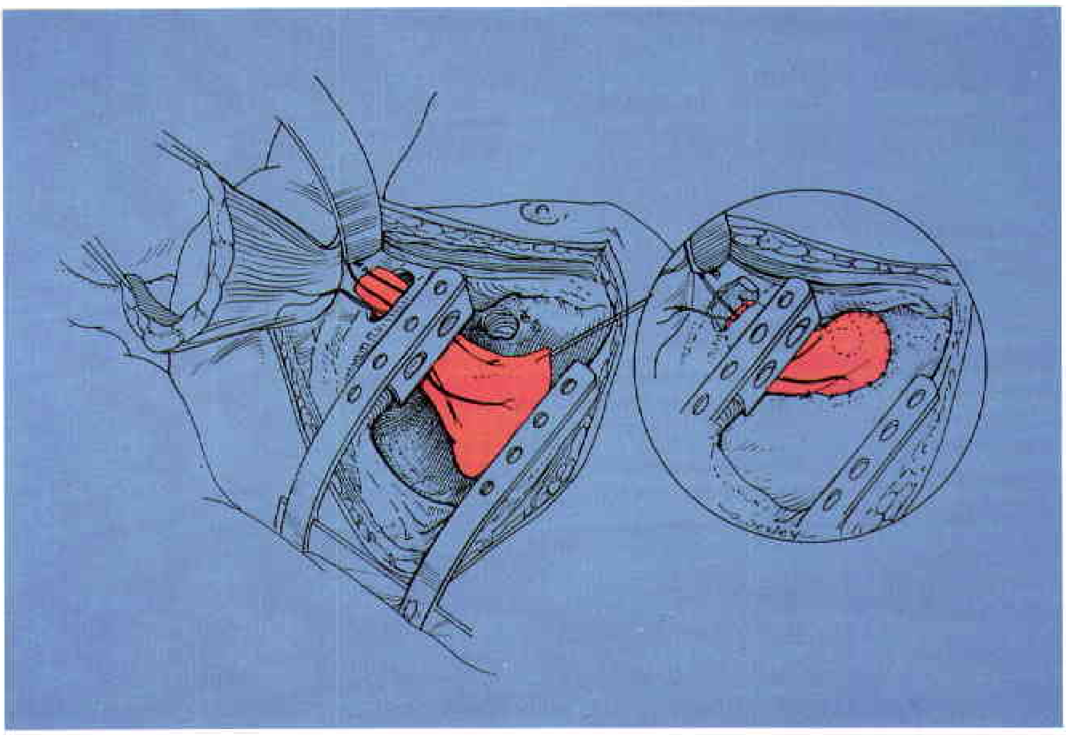
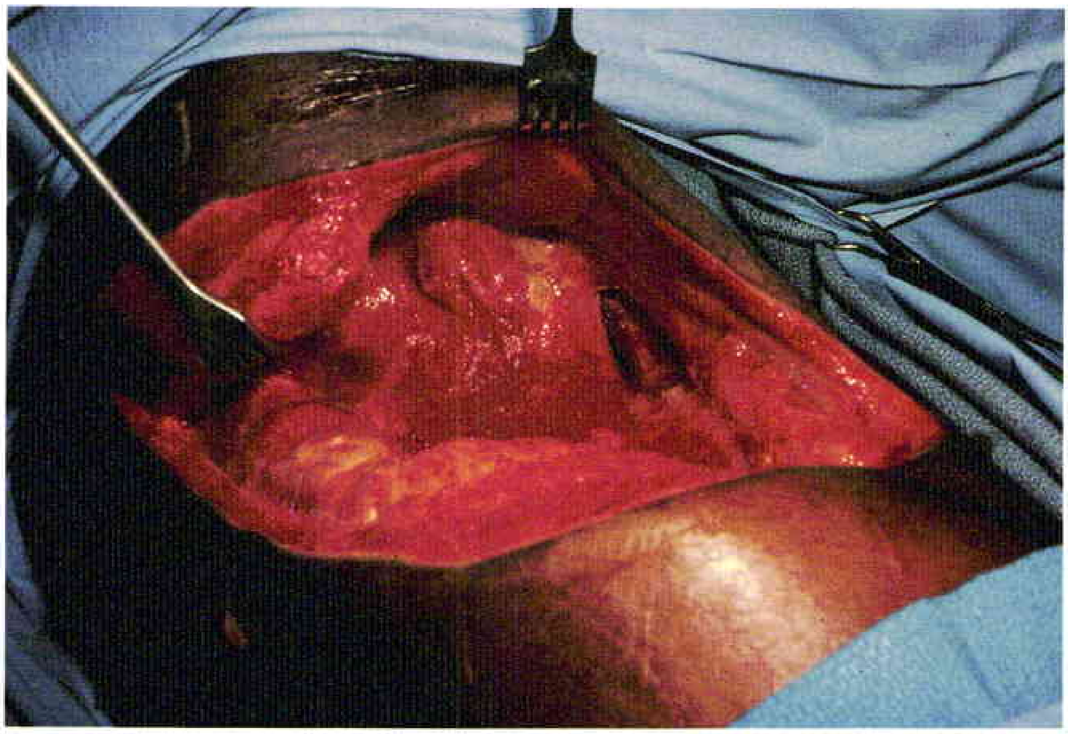
Ribs three through seven have been excised. The serratus muscle has been placed directly into the chest to form a "seal" for the repaired bronchus.





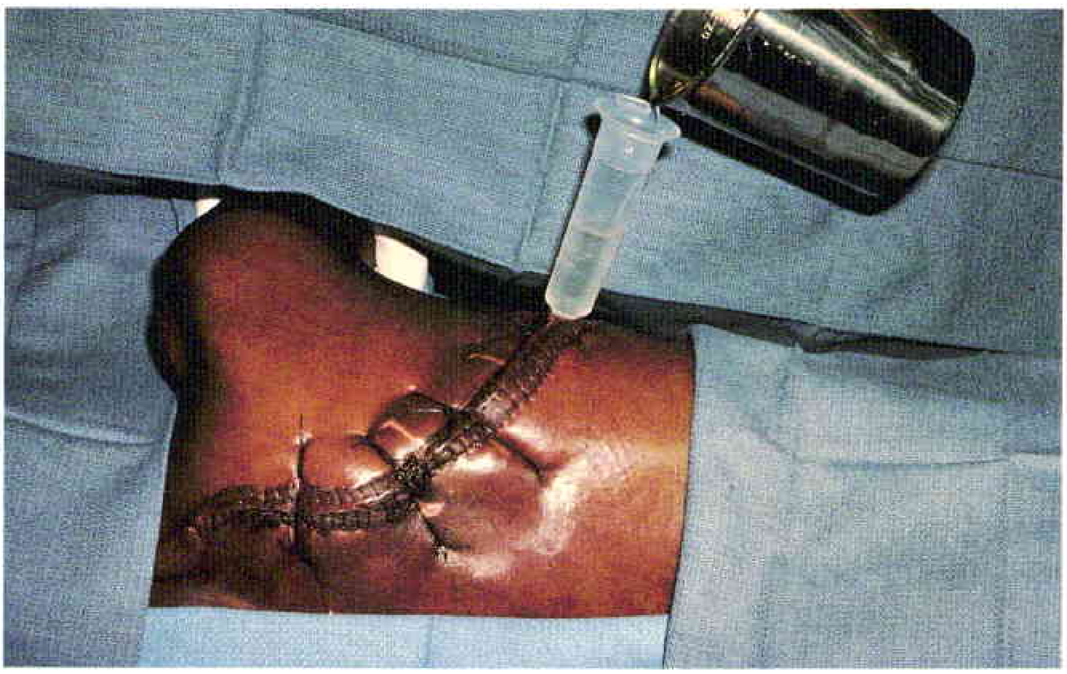
5, 6

Demonstration of the surgical technique showing the "island" serratus anterior muscle, which is supplied by the thoraco-dorsal and long thoracic vessels. The serratus anterior muscle flap is introduced into the chest through a second thoracotomy. The inset muscle is used to bolster the closure of the right mainstem bronchus.



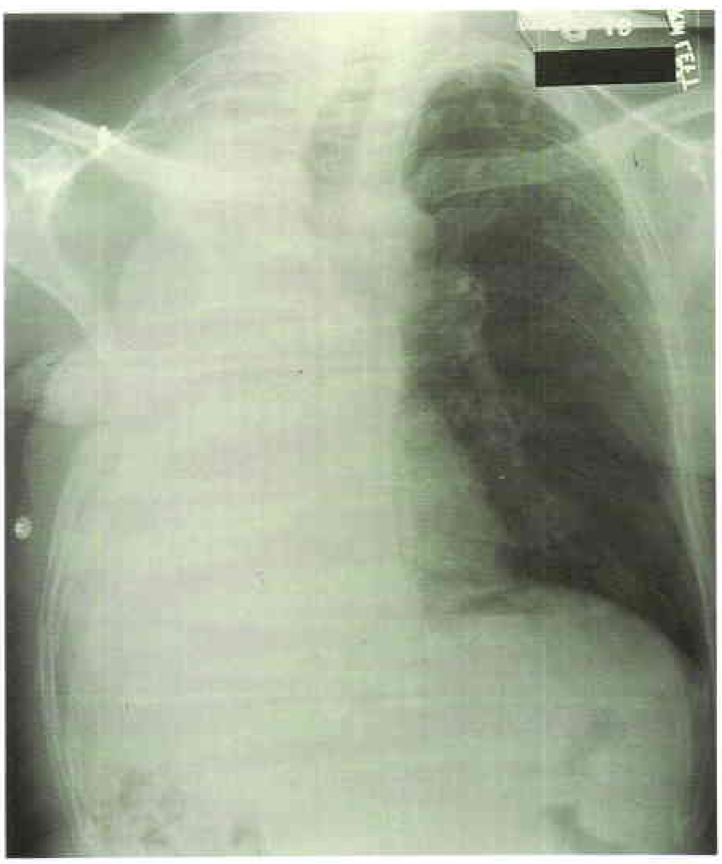
7

Appearance of the wound two weeks following muscle transposition. The wound is "clean" and the serratus muscle is firmly adherent to the secondarily closed bronchus. The entire chest cavity had been treated with frequent changes of moist gauze soaked with diluted Betadine®.



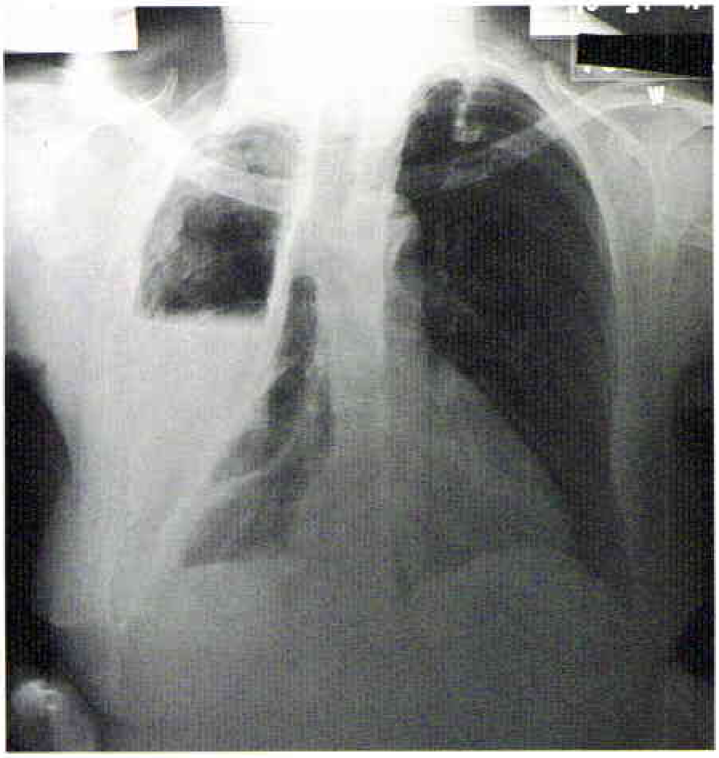
8

The surface wound was then closed directly. The chest cavity was filled with antibiotic solution at the termination of the procedure.



9, 10

Appearance of the surface closure and x-ray one year following the procedure. The Clagett method of obliterating a "clean" thoracic cavity is still an effective procedure. Note the relatively midline position of the air-filled trachea.

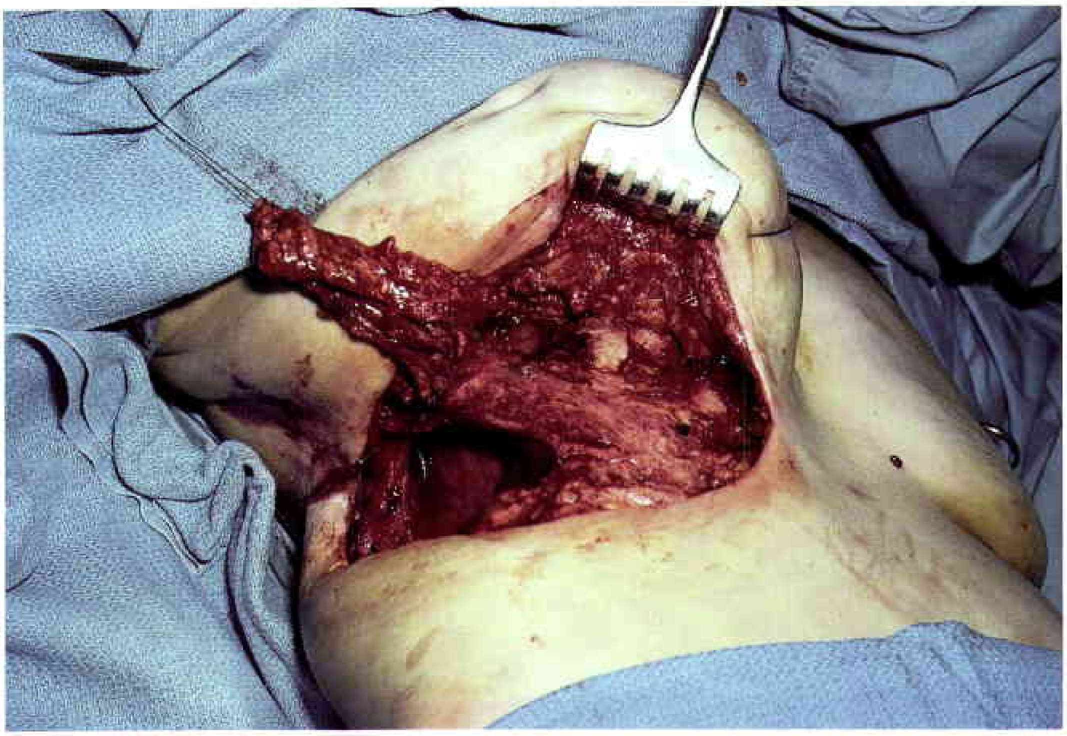


11

Sixty-five-year-old female with arrested tuberculosis which was treated with a therapeutic pneumothorax. Twelve years later she developed an empyema and a bronchopleural fistula. (Case of P.G. Arnold)

12

The empyema was drained with an "open thoracic window" technique which provided complete access to the chest wound. The bronchopleural fistula persists.

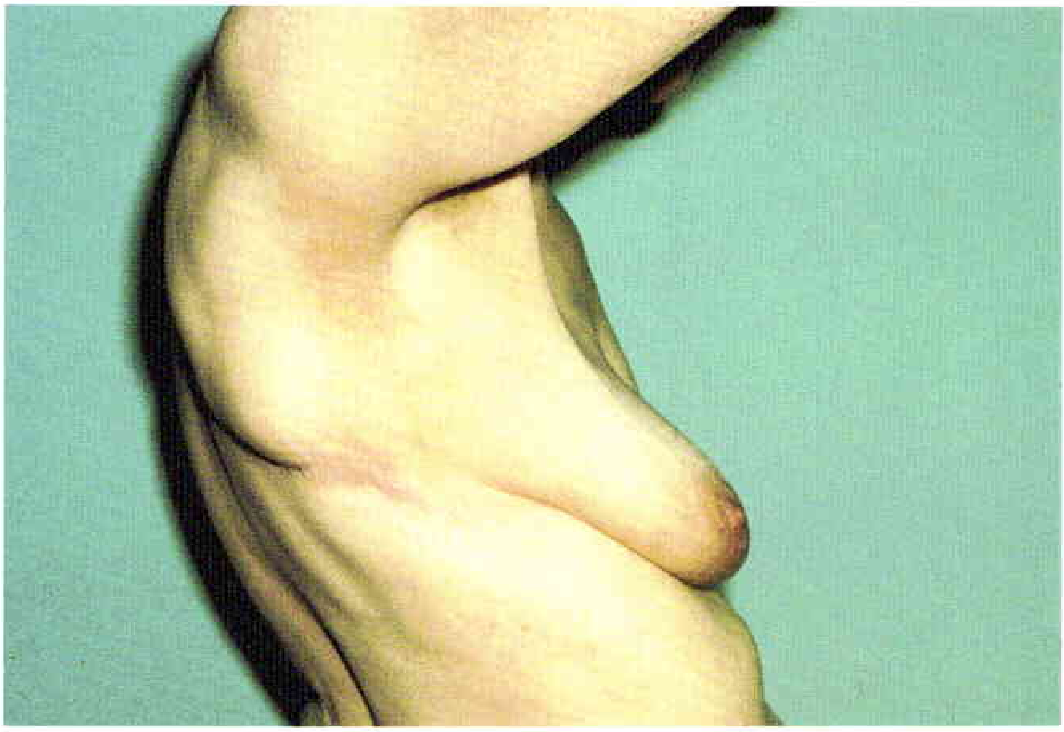


13

A completion pneumonectomy was performed. The latissimus dorsi muscle was mobilized for intrathoracic transposition to reinforce the bronchial stump closure. Approximately seven centimeters of the second rib was resected to allow direct transposition of the latissimus muscle. This "second" thoracotomy prevents kinking of the muscle flap and allows it to reach the main stem bronchus.

14

Following the closure of the broncho-pleural fistula with the latissimus muscle flap, the wound was dressed in an open fashion for several weeks, until the healing of the bronchus was assured and the wound was clean. Once this was accomplished the entire thoracic cavity was filled with an antibiotic solution and the surface wound was closed primarily.



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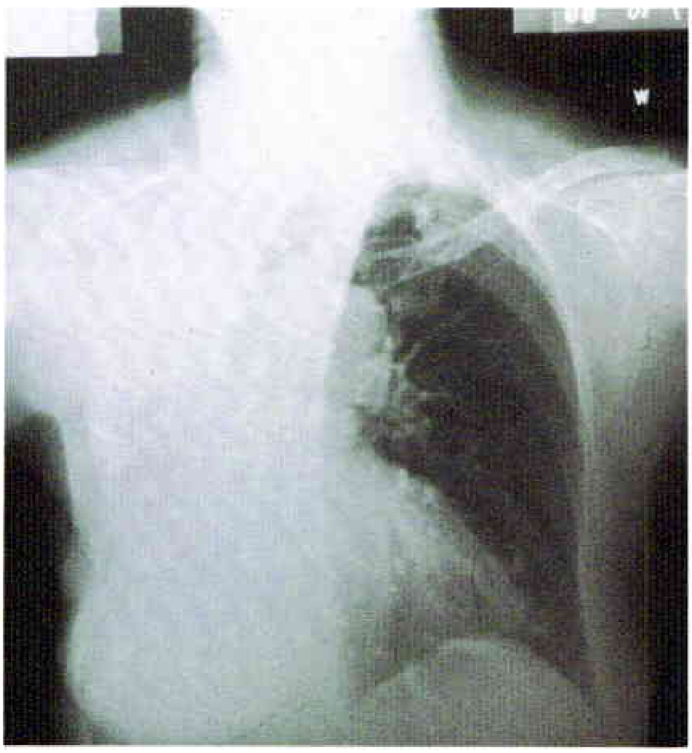
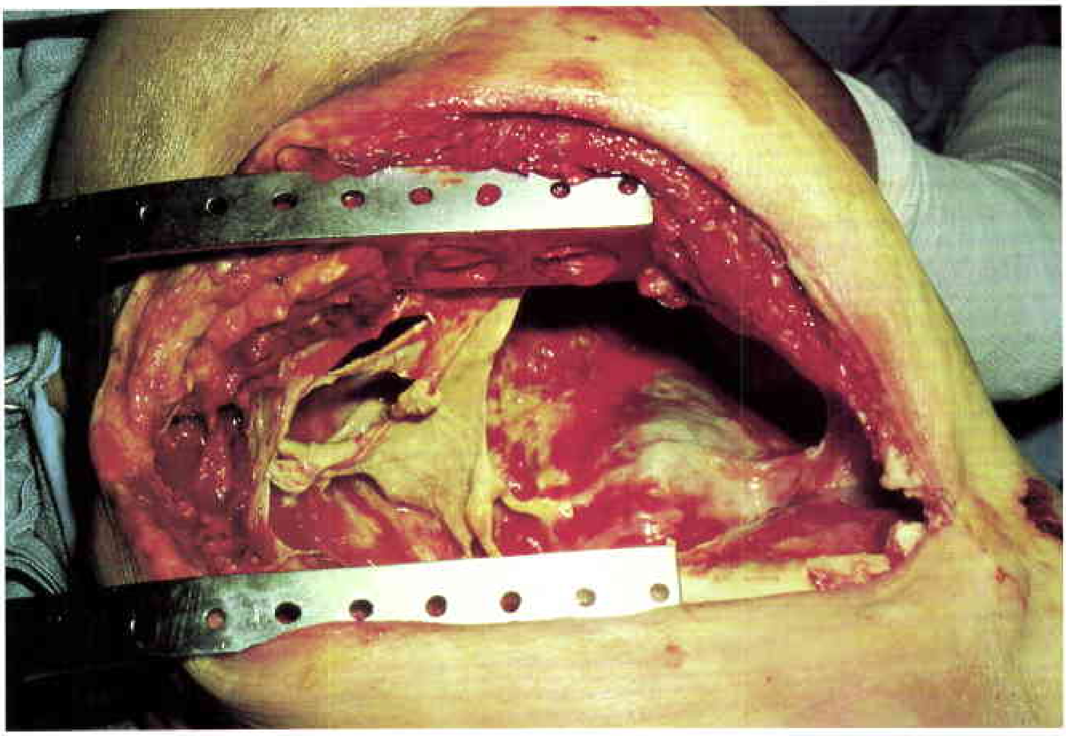
Appearance of the chest wall closure at one year.



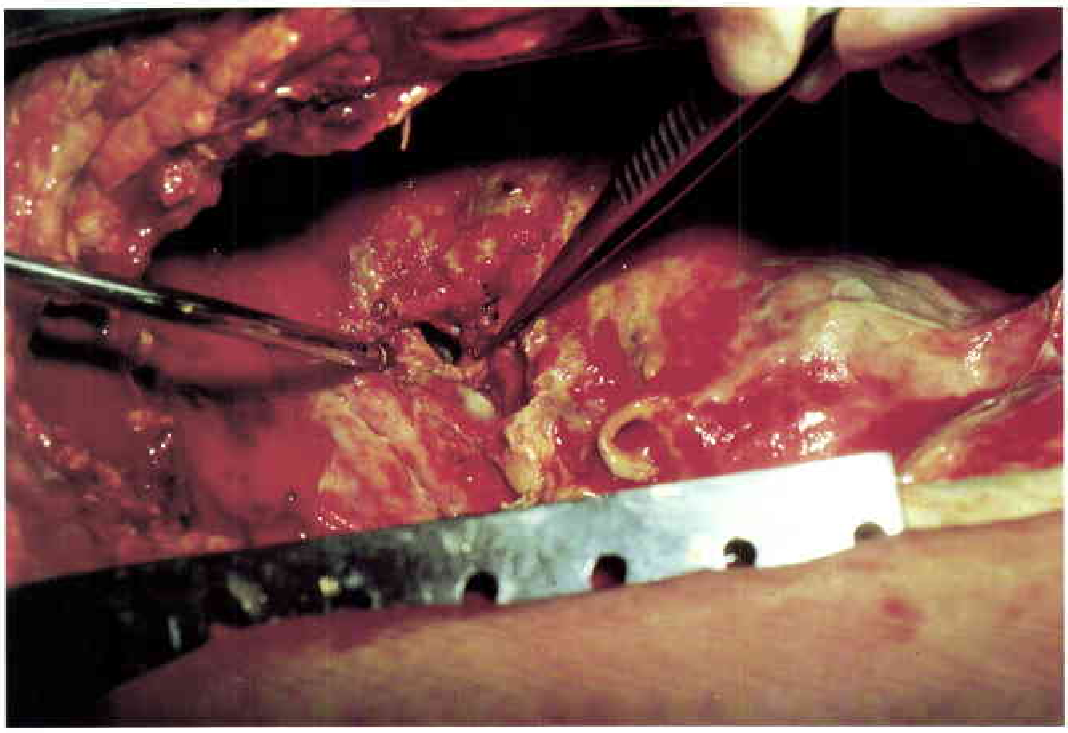
16

This standard chest x-ray demonstrates the healed right main stem bronchus and the obliterated right thoracic cavity at two years.



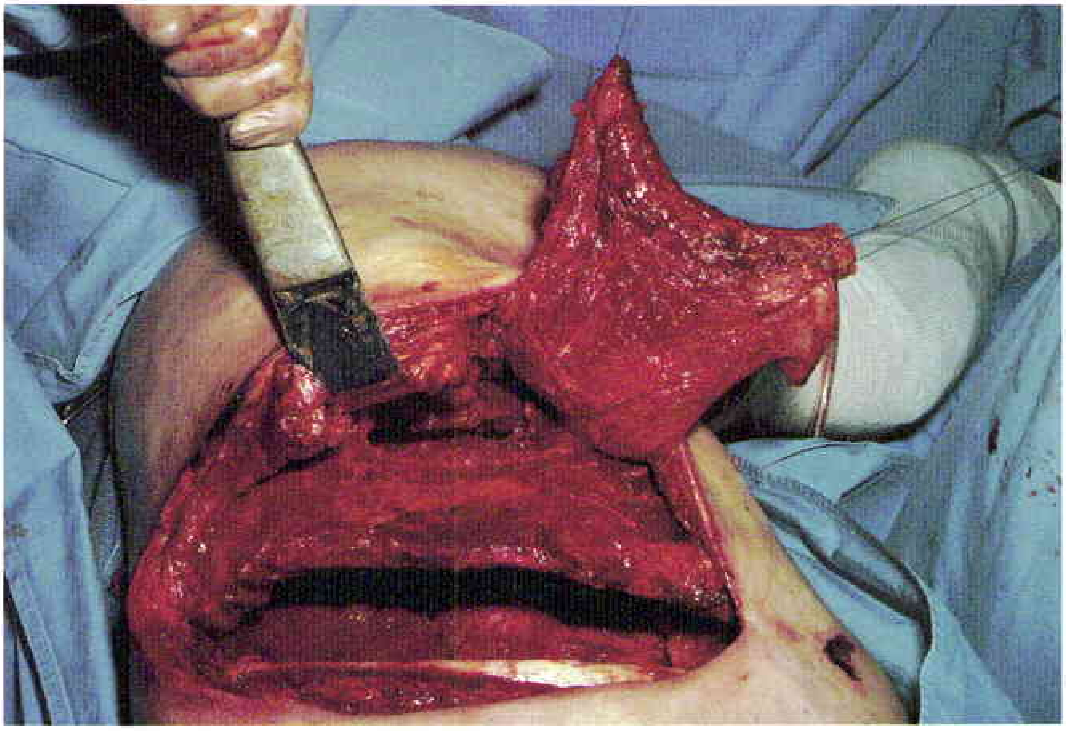
17

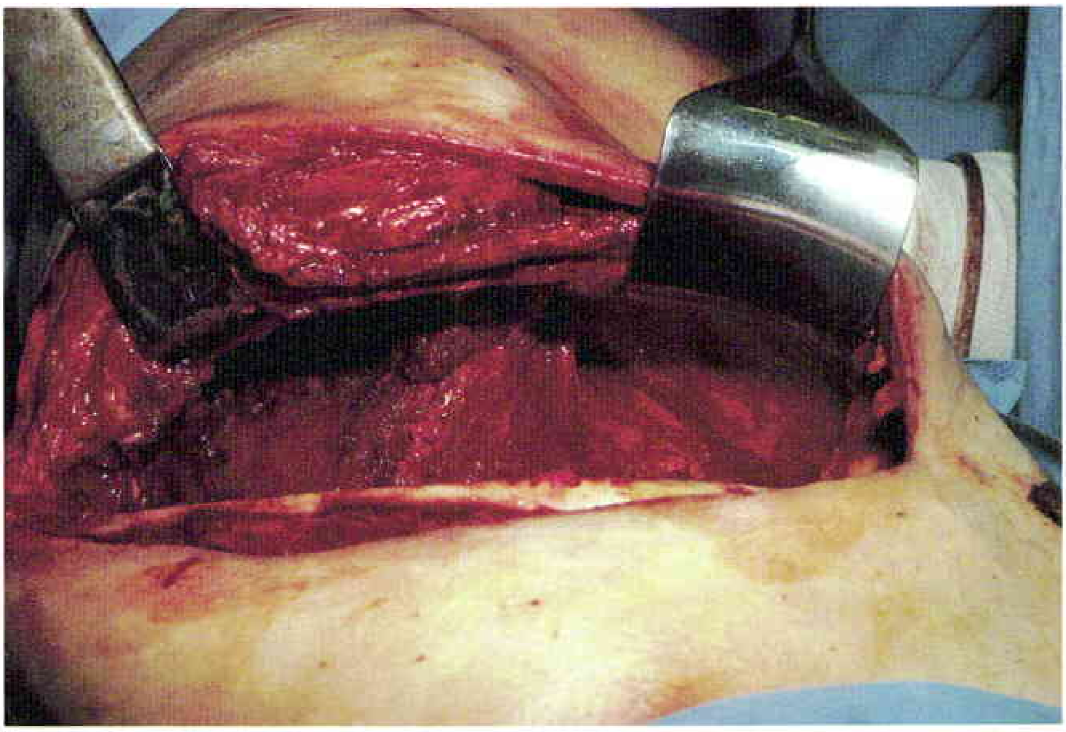
Fifty-seven-year-old man with a post pneumonectomy empyema secondary to a bronchial stump failure. Appearance at the time of empyema drainage and closure of the bronchus. (Case of P.G. Arnold)



18

The bronchial stump failure is demonstrated. During this procedure the chest wound was debrided and the bronchial stump was reclosed and reinforced with a latissimus dorsi muscle flap.





19, 20

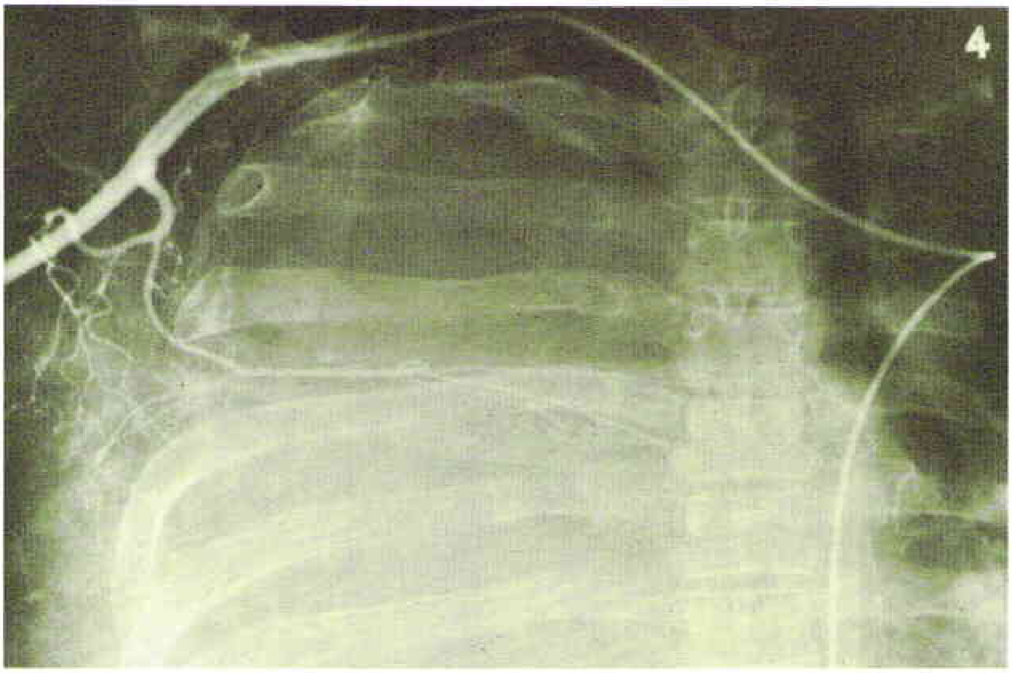
Only the proximal portion of the latissimus dorsi muscle could be mobilized because the muscle had been previously divided at the initial thoracotomy. A small secondary thoracotomy was made in the midaxillary line by removing ten centimeters of the third rib. This allowed a "direct" transposition of the shortened latissimus muscle into the chest for closure of the bronchopleural fistula.

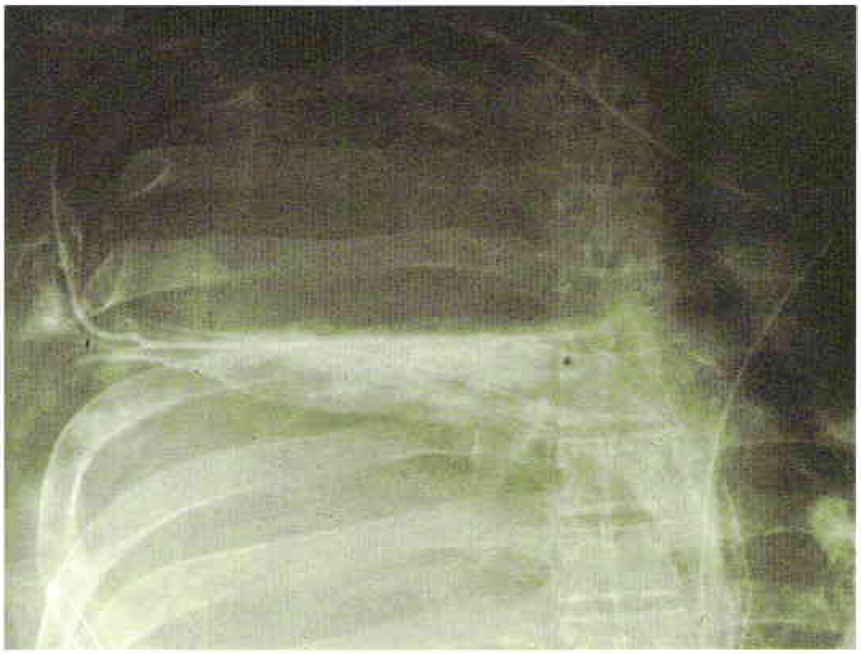
21

The wound was then left open for dressing changes. Note the granulating muscle flap. Once the wound was surgically "clean," the skin edges were closed and the chest cavity was filled with an antibiotic solution. The secondary surface closure is usually done after several weeks, depending on the condition of the chest wound. No attempt is made to obliterate the remaining chest cavity. It is simply closed and filled with an antibiotic solution.

22

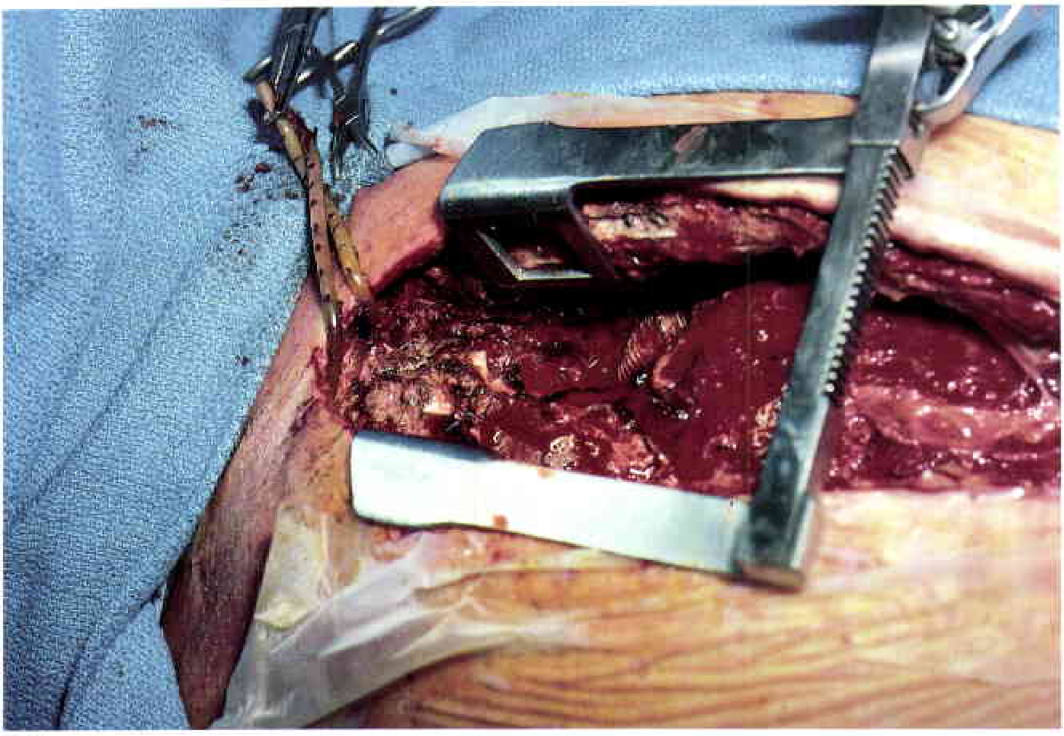
Healed chest closure at nine months.





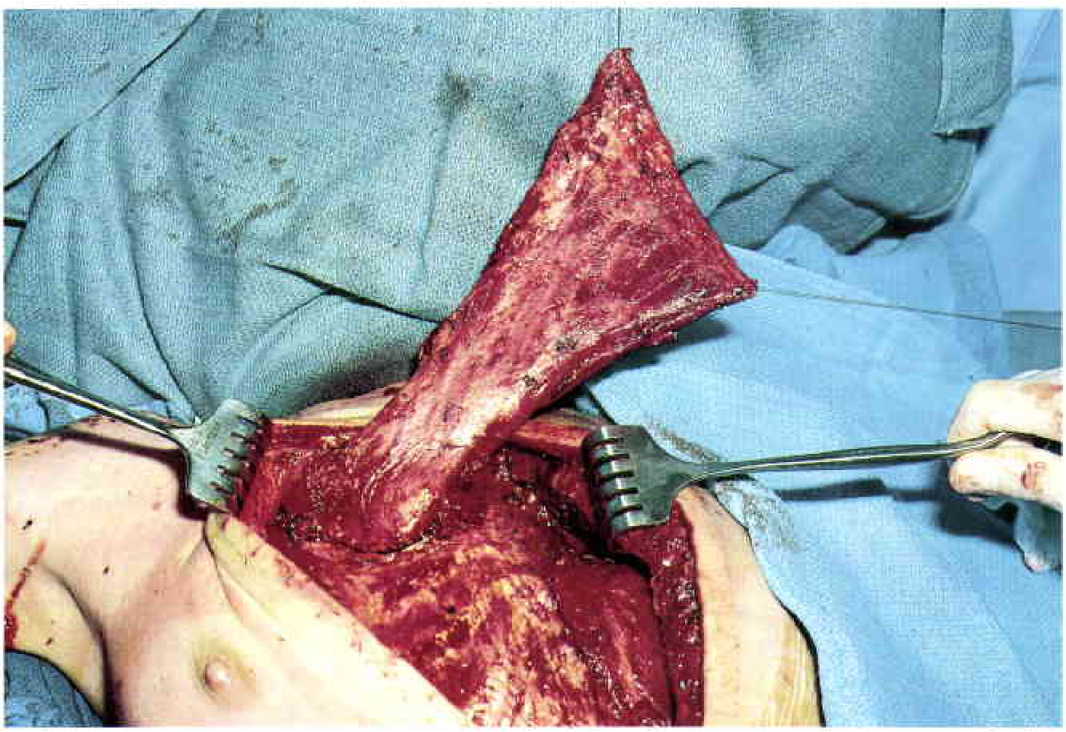
23, 24

Angiogram of the thoracodorsal artery one week following transposition of the latissimus muscle into the chest. Venous phase of the same angiogram.



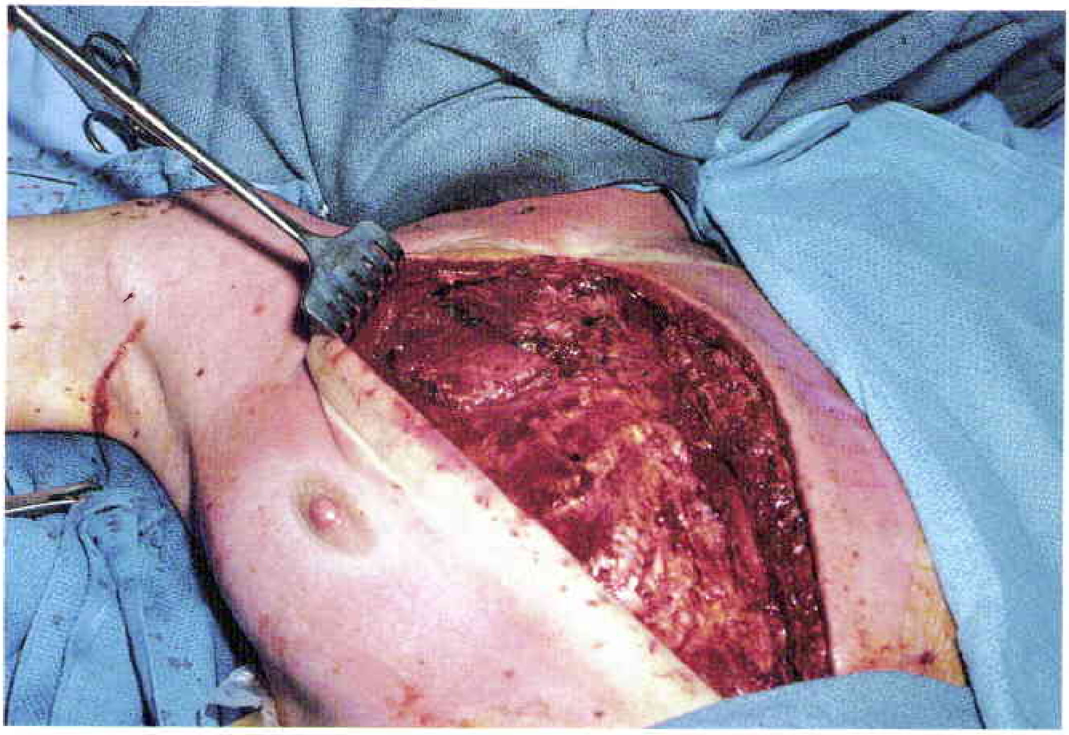
25

Thirty-year-old female who had undergone four major cardiac procedures over a six year period including the correction of a V.S.D., pulmonary artery atresia, and aortic insufficiency. In the most recent procedure a Dacron® conduit was inserted between the right ventricle and the pulmonary artery. It was complicated by an infected false aneurysm of the ascending aorta. The Dacron® conduit is visible in the base of the wound. (Case of P.G. Arnold)



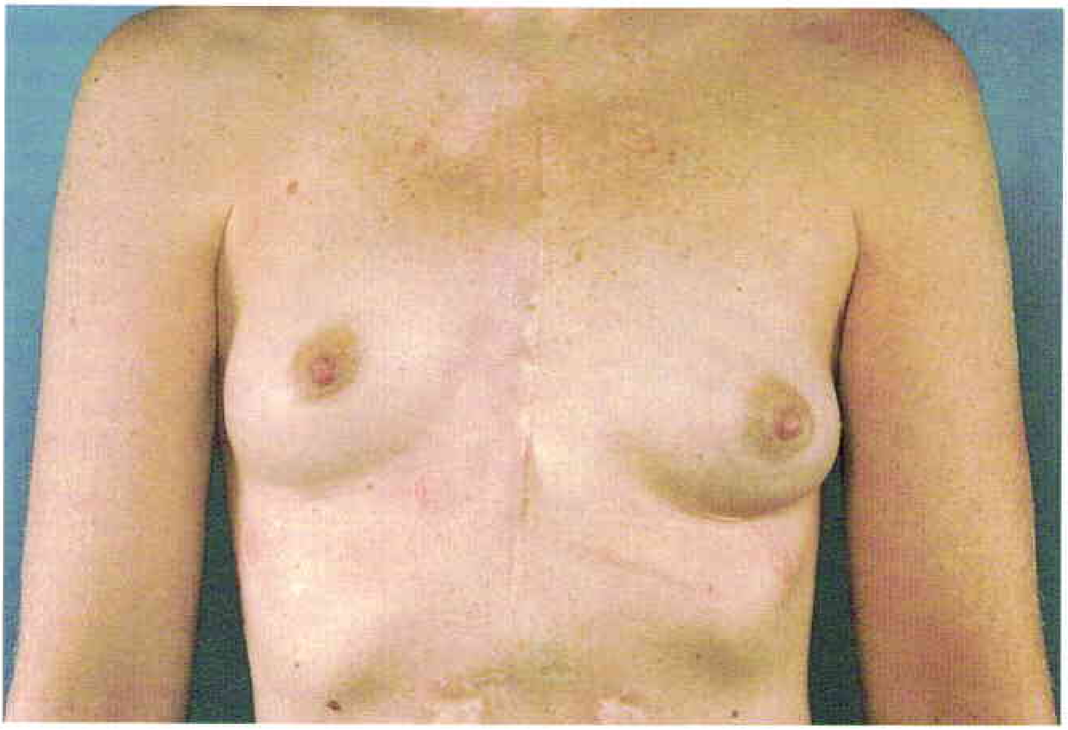
26

The right pectoralis major muscle was raised as an "island" flap to cover the Dacron® prosthesis and the aorta.



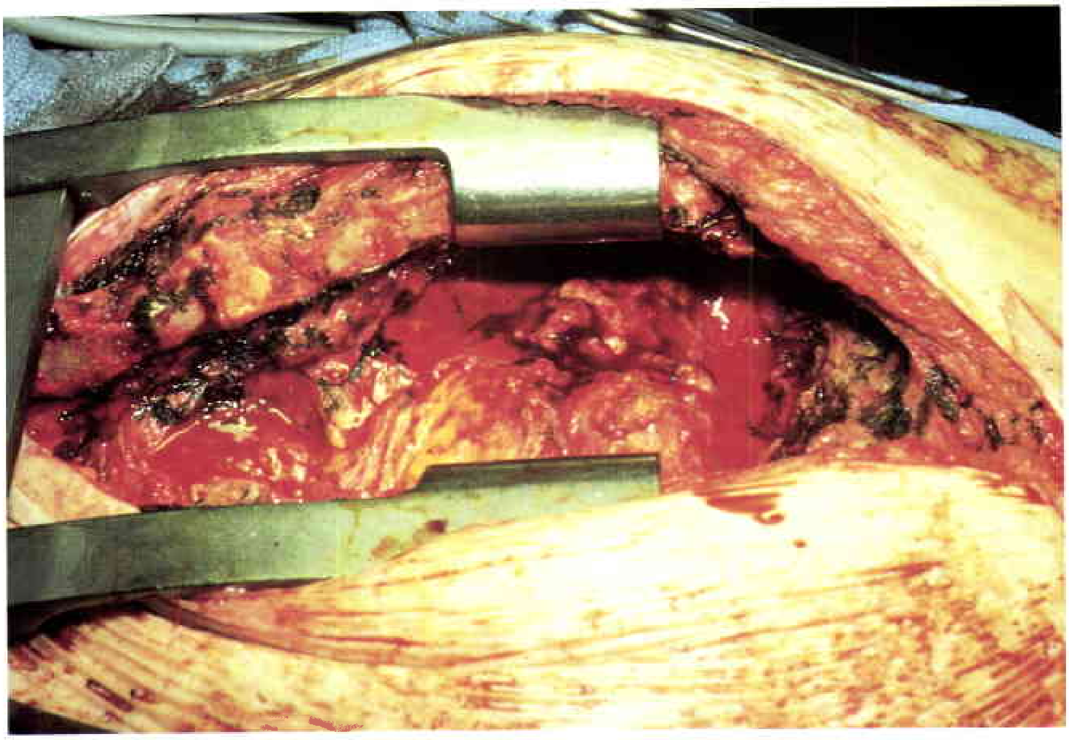
27

The second and third ribs were excised to allow the pectoralis muscle to reach both the infected aorta and the right ventricle.



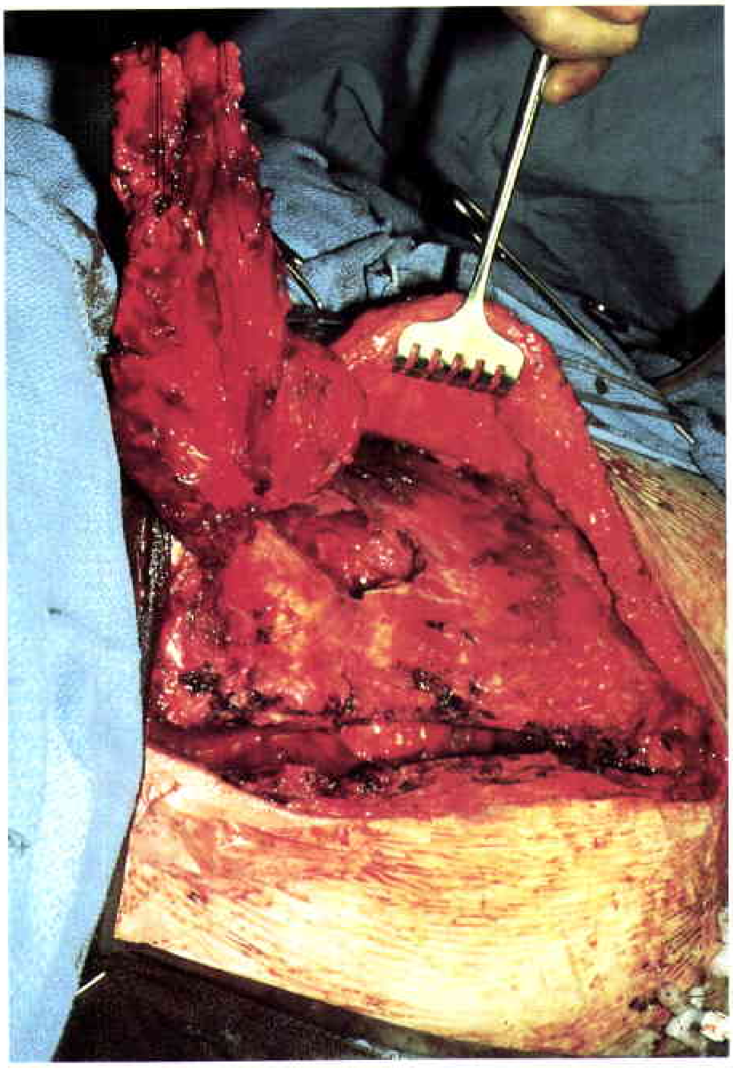
28

Appearance at five years. The wound has remained healed and the patient has been asymptomatic following this closure.



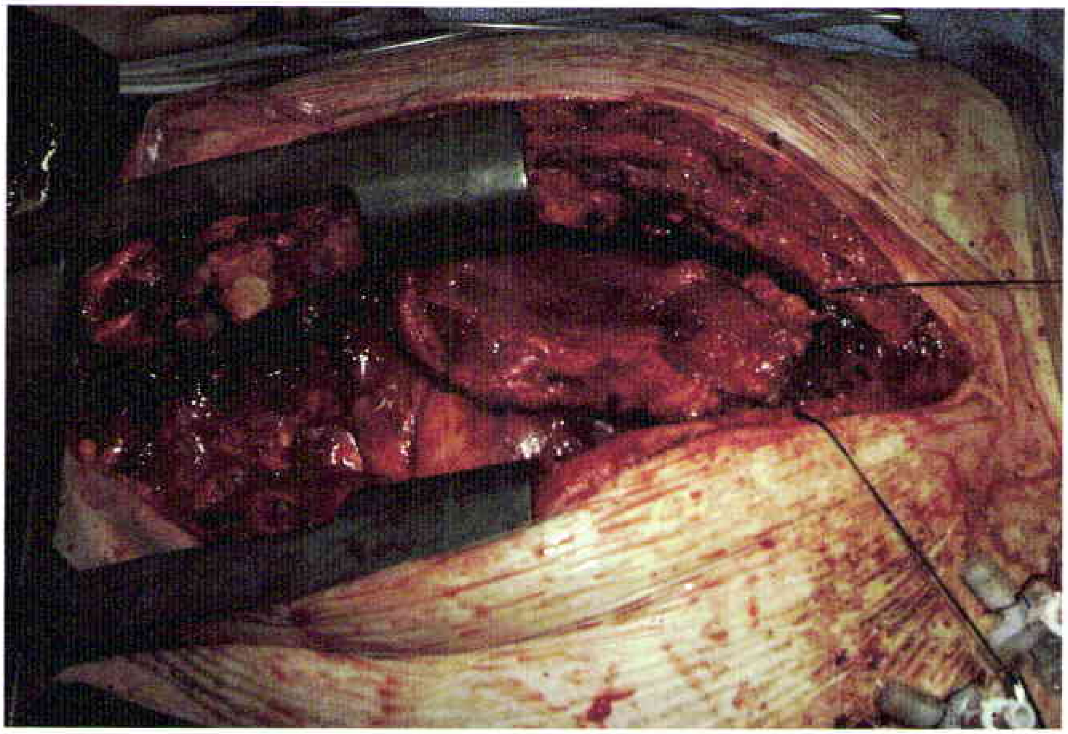
29

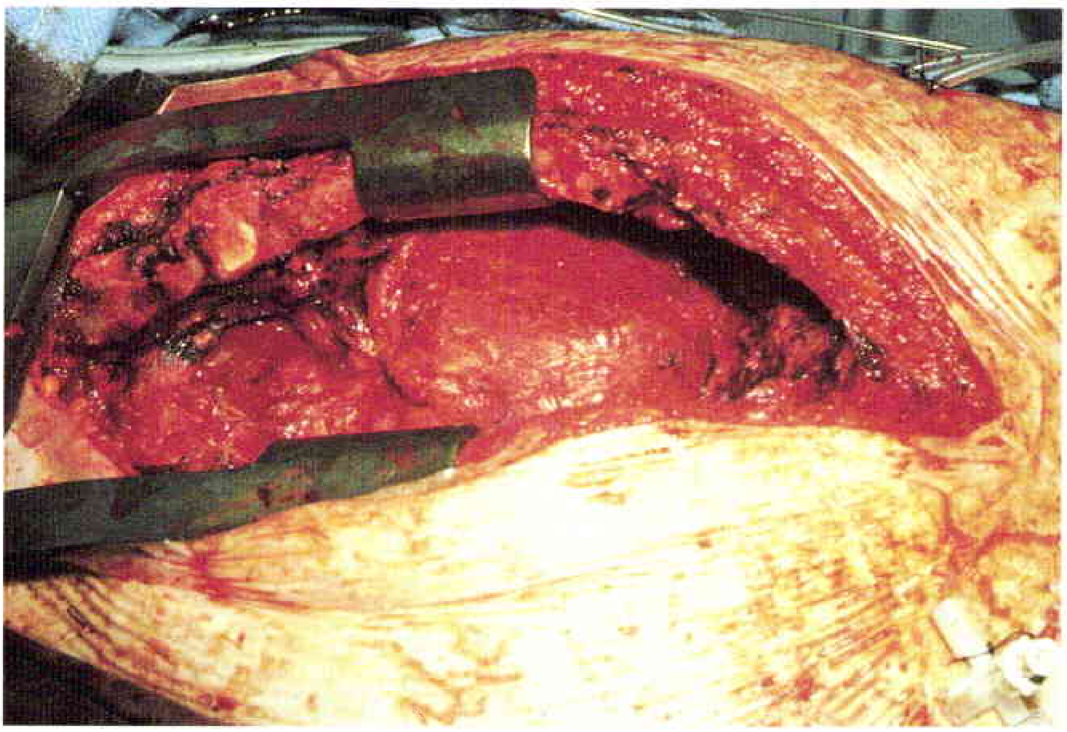
This fifty-four-year-old man had undergone a ventricular aneurysmectomy three years and six years earlier. At this exploration for a left ventricular pseudoaneurysm an abscess was found surrounding the heart. This was apparently related to the Teflon® felt reinforcement pads. No bacteria were found on the gram stain, but the culture was positive for Klebsiella pneumoniae. (Case of P.G. Arnold and H. Schaff)



30

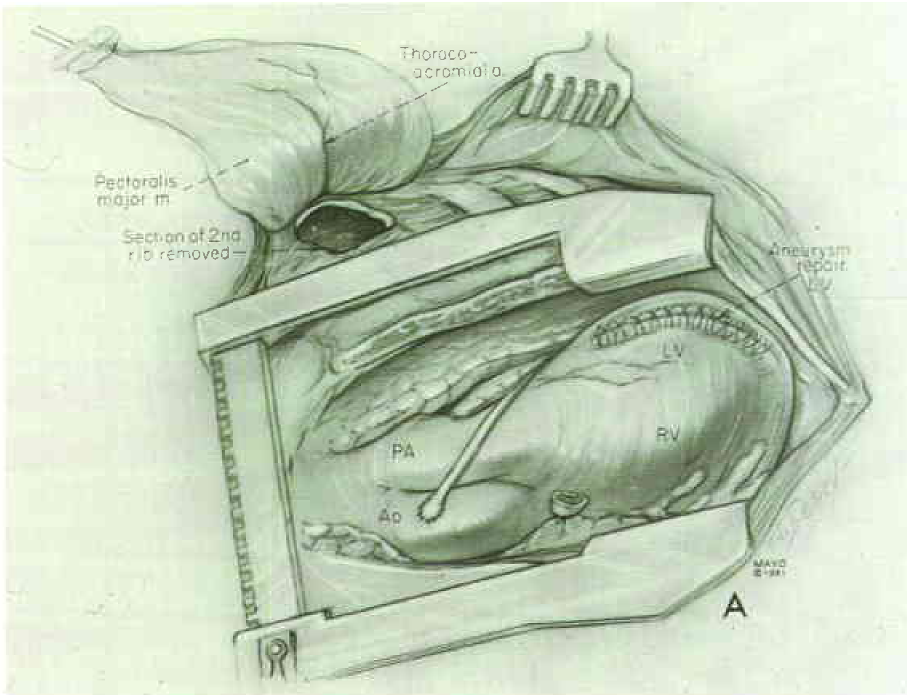
An "island" pectoralis major muscle flap was elevated, at the time of the secondary ventricular closure. The muscle was divided from its humeral insertion and passed into the chest by removing a twelve centimeter segment of the third rib.

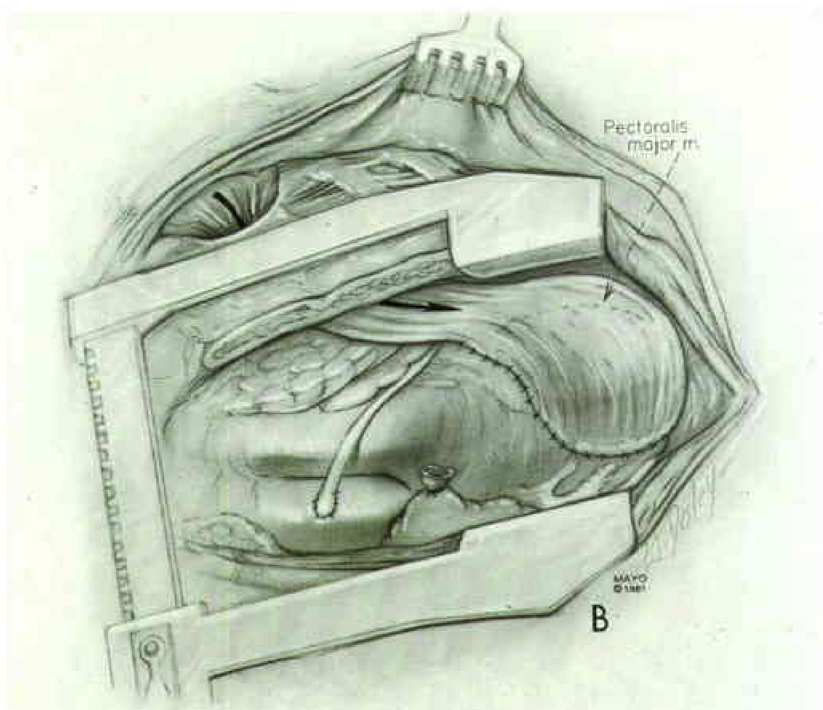




31, 32

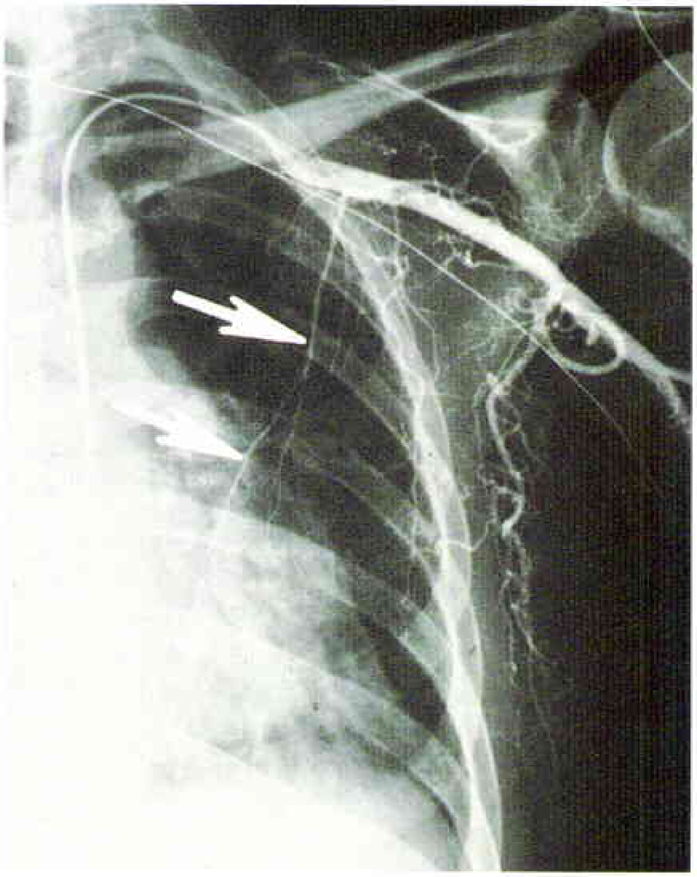
Pectoralis muscle passed to its intrathoracic location and sutured over the heart to reinforce the ventricular repair.





33, 34

Illustrations of the procedure. After a right atriofemoral artery bypass was established the aneurysm was opened and resected along with the previously placed Teflon® felt pads. The fibrous edges of the left ventricle were then closed with multiple layers of 0 Prolene® without using felt pads. The pectoralis muscle was used to reinforce the left ventricular closure.



35

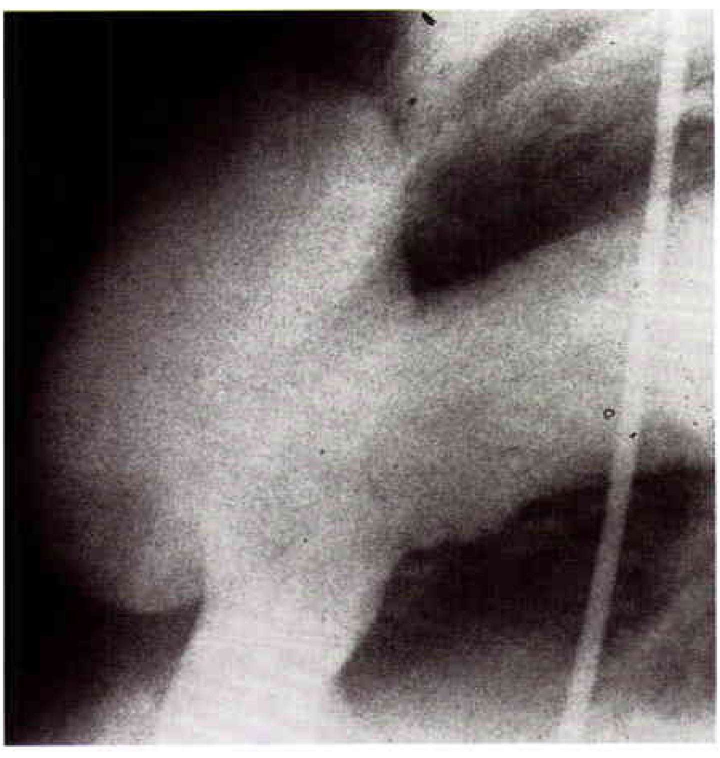
Arteriogram demonstrating the patency of the thoracoacromial vessels and the intrathoracic location of the pectoralis major muscle.

36

Appearance two years following surgery. The patient's chest pain was completely relieved and he returned to full activity. A two dimensional echocardiogram demonstrated no evidence of a recurrent pseudoaneurysm.

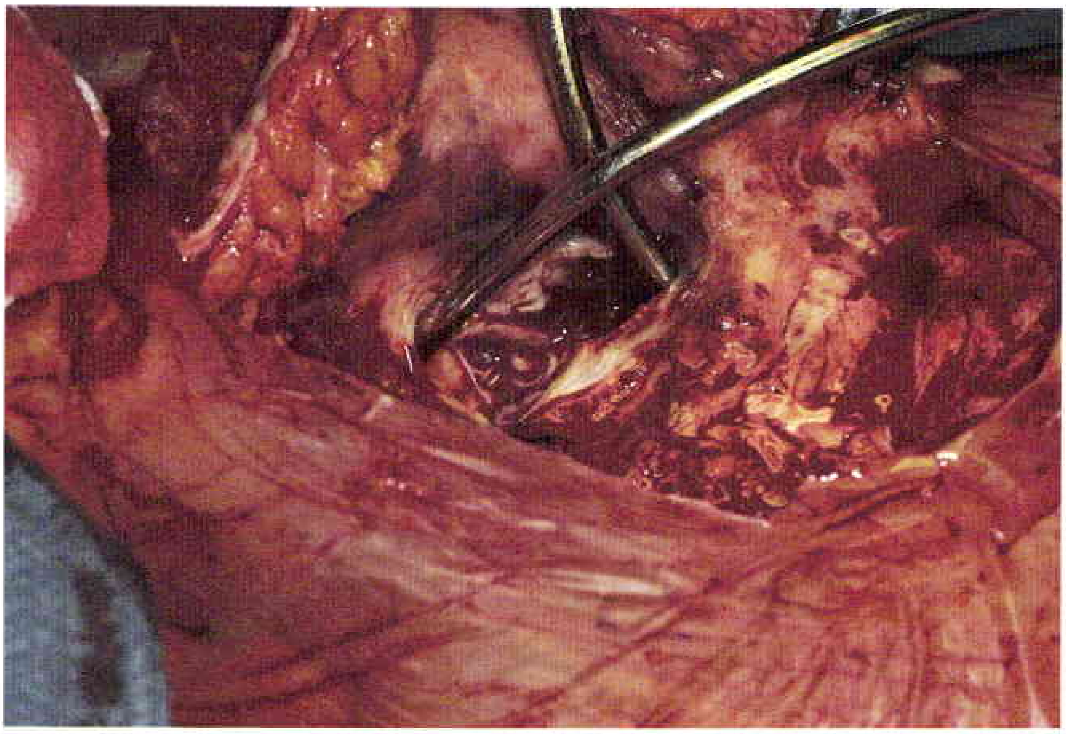
37

Forty-five-year-old woman who had previously undergone a right radical mastectomy and closure of an irradiation ulcer by centralizing the remaining left breast. When the patient was first seen she gave a history of ''bleeding a lot'' from the ''blood blister'' at the margin of the left breast flap. (Case of P.G. Arnold)



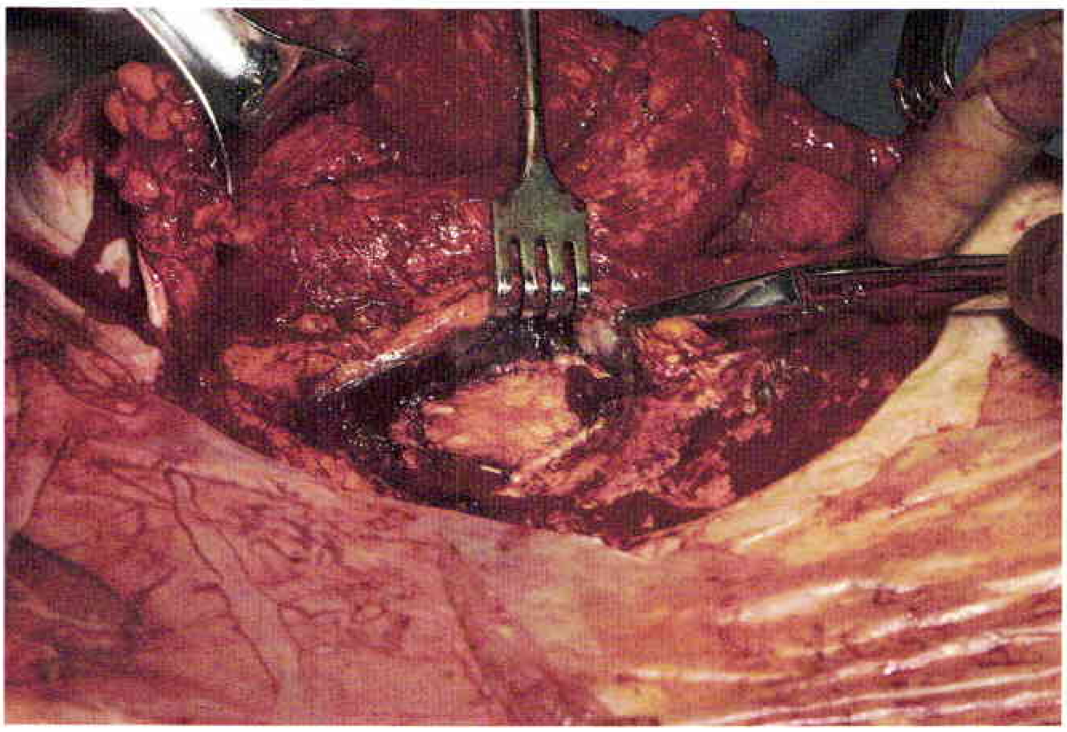
38

Lateral view of an angiogram demonstrating a large aneurysm of the pulmonary outflow tract. The aneurysm had eroded through the irradiated and infected sternum. The ''blood blister'' proved to be the surface of the pulmonary artery aneurysm.



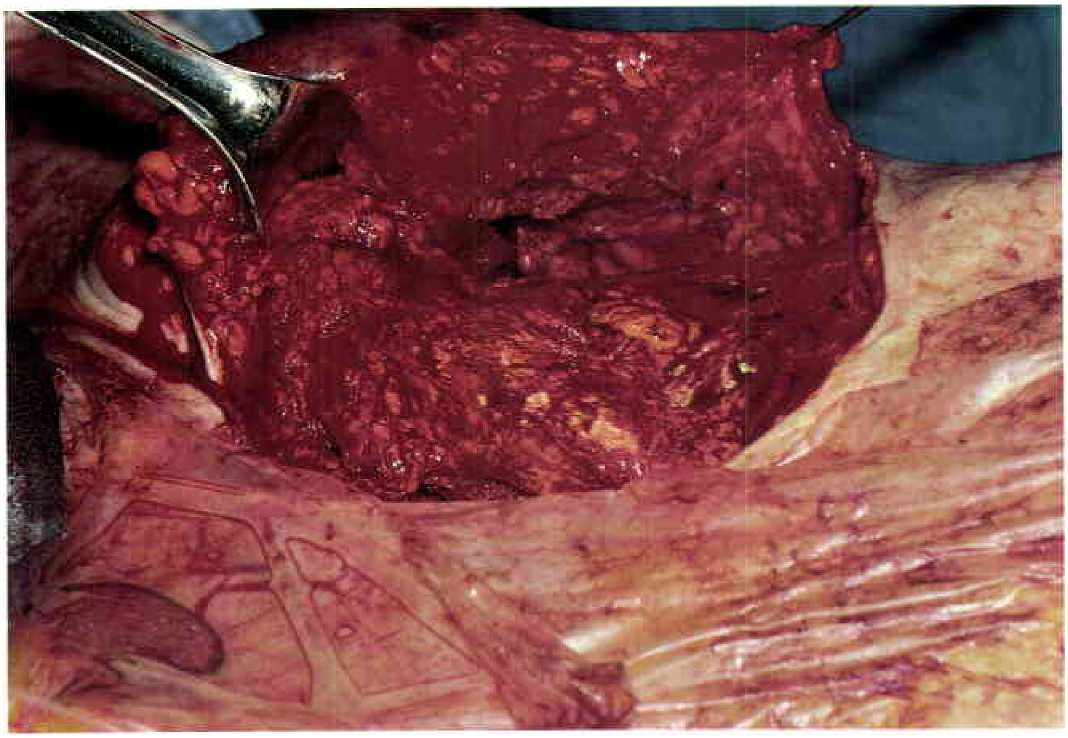
39

Opened aneurysm with the aspirators in the base of the pulmonary outflow tract. The aneurysm wall is reflected superiorly.



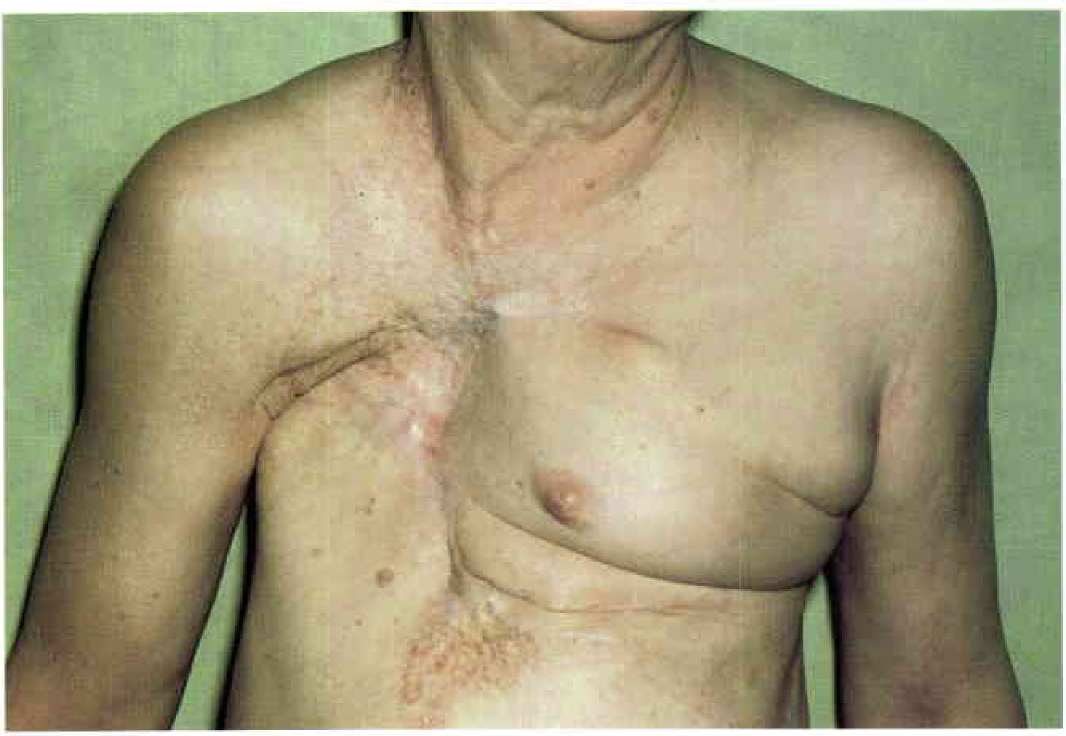
40

The anterior wall of the aneurysm was resected and repaired with a fascia lata graft. The adjacent infected sternum was also resected.



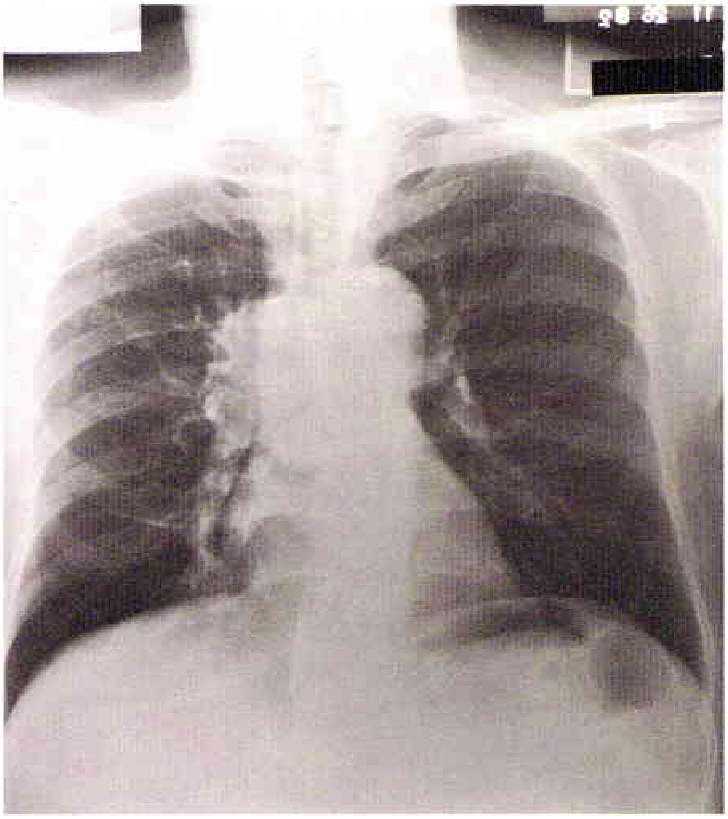
41

The pectoralis muscle was transposed into the chest to reinforce the vascular repair and vascularize the fascia lata graft.



42

Appearance of the closure at two years. Neither the infection or the aneurysm has recurred.

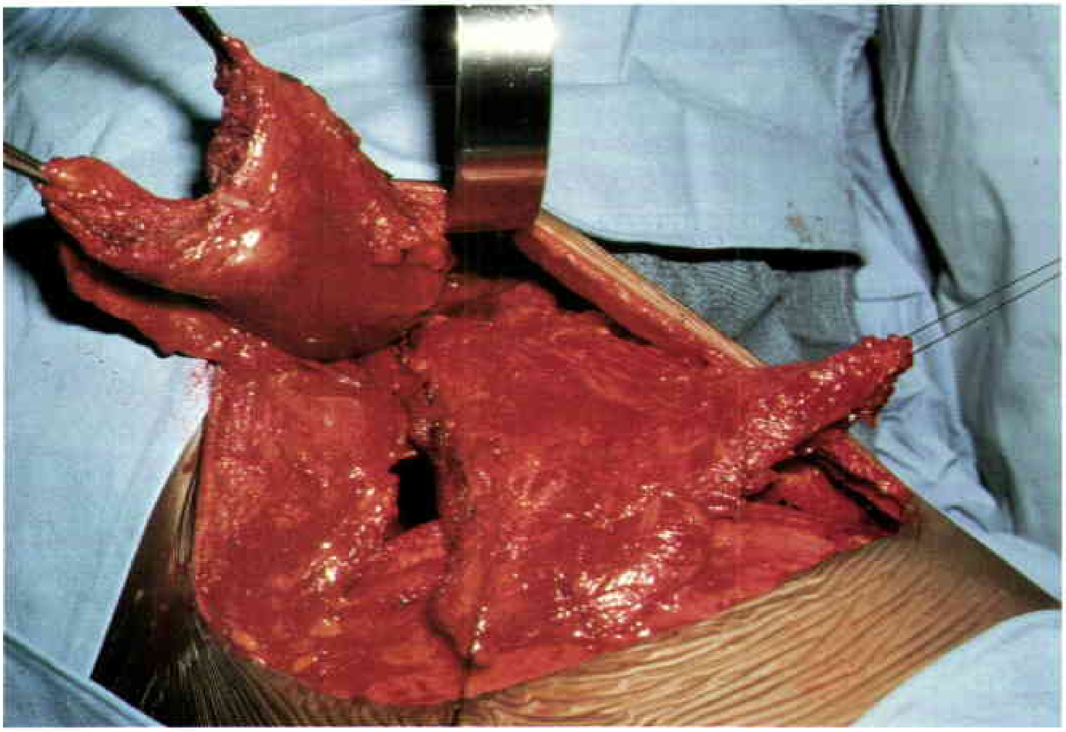


43

Chest x-ray of a forty-nine-year-old man with a squamous cell carcinoma of the right main stem bronchus extending onto the trachea. (Case of P.G. Arnold and P. Pairolero)

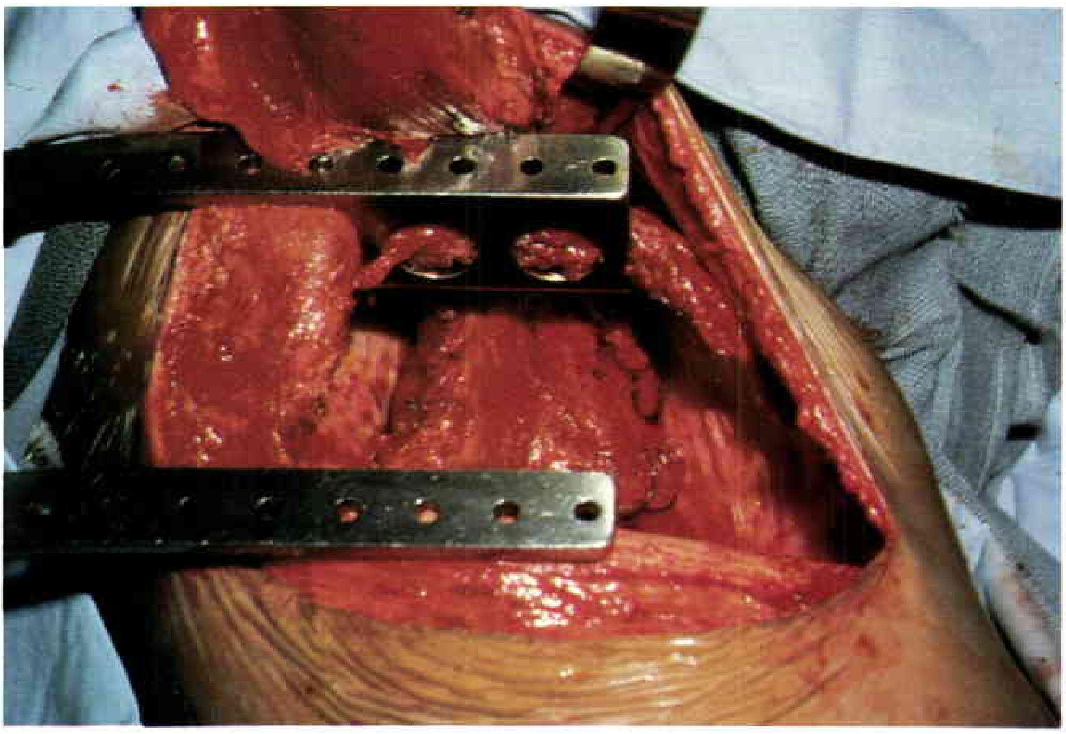
44

Endoscopic appearance of the large tumor which virtually occludes the right mainstem bronchus and partially fills the trachea. The left mainstem bronchus is barely visible.



45

Mobilization of the transected latissimus dorsi muscle and the entire serratus anterior muscle at the time of the right posterolateral thoracotomy.



46

A "sleeve" pneumonectomy has been completed. The serratus anterior muscle has been transposed intrathoracically to reconstruct the ten centimeter tracheal wall defect.

47

Chest x-ray four years postoperatively. The serratus muscle flap covering the tracheal defect was completely reepithelialized with columnar epithelium.

48

Appearance of the patient four years postoperatively.

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