Review Article

Second surgery for complications of major pulmonary resection: the knack of air plombage in thoracoplasty

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Abstract: Air plombage is a surgical procedure that reduces the pleural space. In 1953, Dr. Chamberlain designed the original "extraperiosteal plombage" to prevent complications after pulmonary segmentectomy for tuberculosis. This surgical technique was developed to prevent the formation of an intrapleural pocket of dead space, and allow collapse of the cavity and obliteration of the extrapleural space. Thus, this technique has been called as "(extraperiosteal) air plombage." In Japan, a modified air plombage called "Kinchu method" has been performed. The indication for air plombage is as follows: (I) the remaining pulmonary parenchyma after resection does not expand and fill the residual pleural space, (II) large raw surfaces of pulmonary parenchyma remain in a plane, which cannot easily contact the chest wall, (III) there is an excessive air leak from the parenchyma. Surgical procedure is as follows: portion of the ribs above the pleural space are stripped subperiosteally, leaving attached periosteum on their outer surfaces. The size, shape, and location of the "resultant air pocket" is made to fill the defect left by lung resection. The pleura, periosteum, and intercostal muscles and facia drop into the pleural space and contact the resected surface of pulmonary parenchyma. However, care should be taken with regards to pre-, intra-, and post- operation. Particularly, to minimize atrophic and deformative changes in late phase after air plombage, it is important to avoid dissecting the costal periosteum and intercostal muscles of lower (the 8th–12th) ribs.

Keywords: Air plombage; postoperative complication; pulmonary resection; thoracoplasty

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Introduction

Air plombage is a surgical procedure that reduces the pleural space (e.g., empyema cavity) (1-3). Specifically, extrapleural air plombage is performed as follows: there is empyema cavity in pleural space and lung is deflated, the space between the costal periosteum—intercostal muscles—ribs and thickened parietal pleura are dissected, the extrapleural space ("air pocket") is then filled with various materials to collapse the underlying cavity. As pulmonary function is preserved to some extent, this surgical technique can be commonly used in patients with more limited cardiopulmonary reserve or comorbidities (4). The word "plombage" means sealing or filling; extrapleural plombage could be performed as a single localized procedure. This surgical technique was developed to prevent the formation of an intrapleural pocket of dead space, and allow collapse of the cavity and obliteration of the extrapleural space. Thus, this technique has been called as "(extraperiosteal) air plombage."

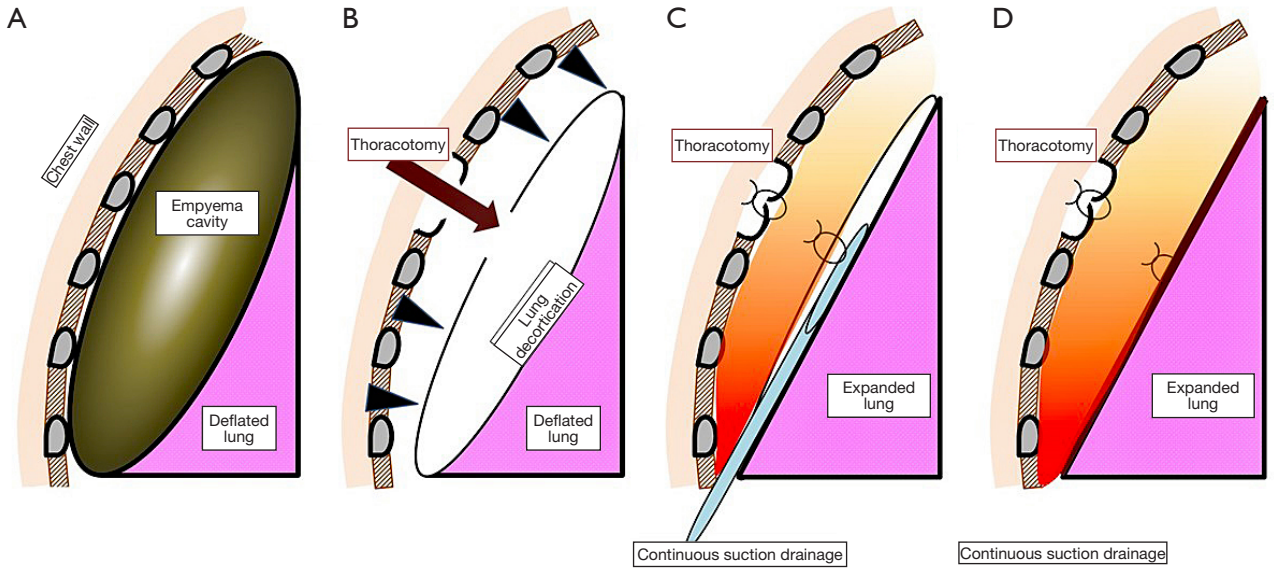

Figure 1 The extrapleural air plombage is shown: (A) there is empyema cavity in pleural space and lung is deflated; (B) the space between the costal periosteum—intercostal muscles—ribs and thickened parietal pleura are dissected; (C) the extrapleural space ("air pocket") is then filled with various materials to collapse the underlying cavity; (D) Pulmonary function is preserved to some extent.

History

In 1953, Dr. Chamberlain (5) designed the original "extraperiosteal plombage" to prevent complications after pulmonary segmentectomy for tuberculosis. This paper referred to the use of extraperiosteal plombage for subscapular collection of blood in the patient. Afterwards, in 1959, Dr. Pate (6) performed a retrospective study on air plombage. In this paper, 61 patients with concomitant air plombage were compared with 313 patients without a collapse procedure for upper lobe resections. The overall complication rate was only 1.6% in the air plombage group, but 19.3% in the no air plombage group. Additionally, only 1.6% of the air plombage group patients required further surgical treatment compared to 14% patients of the no air plombage group. Here, we showed typical diagrams on the extrapleural plombage (*Figure 1*).

In Japan, a modified air plombage called "Kinchu method" has been performed (7-9) (*Figure 2*); that is, "modified extraperiosteal plombage". The "Kinchu method" is performed as follows: portions of the ribs above the pleural space are stripped subperiosteally. Then, the bloody exudate pools in the extraperiosteal space (air pocket). The compression from accumulation of bloody exudate minimizes and collapses the pleural space. Postoperatively, "air pocket" slowly fills with blood and fibrin. It decreases in size as the lung heals and pleura is pushed up by the expanding lung (6). These papers claimed that "Kinchu method" is an excellent surgical procedure, which could cure empyema with fistula, particularly, for patients in whom lung decortication could not be performed. There is no deformation of thoracic wall deformity and no decline in respiratory function in this procedure. Later, the designation of this procedure was changed from extraperiosteal "air" plombage thoracoplasty to extraperiosteal "fluid" plombage thoracoplasty (10).

From historical perspective, it may be mentioned that conventional plombage therapy has been completely abandoned as a treatment of residual pleural spaces, and removal of the foreign materials is recommended whenever such patients are identified, if the operative risk is acceptable (11,12).

Rationale

First, it allows normal tissue to attach directly on the raw surface of the air leak at the pulmonary parenchyma or resected line of the lung. These cover multiple minute air leaks and aid in wound healing by preventing overextension which causes persistent leaks or primary disease.

Second, it gives the chest wall certain amount of flexibility. Thus, an excessive intrapleural negative

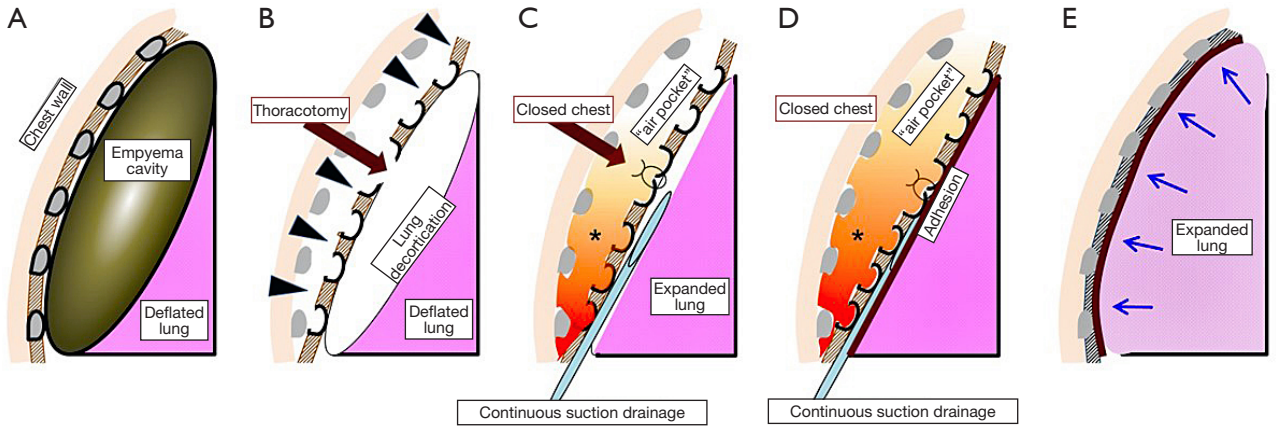

Figure 2 The "Kinchu Method" is shown: (A) there is empyema cavity in pleural space and lung is deflated; (B) portions of the ribs above the pleural space are stripped subperiosteally; (C) bloody exudate (asterisk) pools in the extraperiosteal space (air pocket); (D) "air pocket" slowly fills with blood and fibrin, and (E) it decreases in size as the lung heals and pleura is pushed up by the expanding lung.

pressure is reduced during forced inspiration, and it tends to minimize the passage air leak from small bronchi and pulmonary parenchyma.

Third, the procedure adjusts the shape of the intrapleural space to fit the abnormal shape of pulmonary surface resulting from resection, which can attach to all raw pleural surface, and obliterate the pleural space.

Advantages (1-3)

- First, no deformity of rib cage and scoliosis in short term;
- Second, less invasive, and traumatic than thoracoplasty;
- Third, somewhat automatically reversible: dissected space back against the ribs obliterating the pleural space after lung re-expansion due to the sealing of air leak and healing of the raw surface;
- Fourth, little paradoxical motion of the thoracic wall because of blood, fibrin, and trapped air in a closed space covered by rib cage;
- Allows for a much larger dissecting under simplified postoperative management compared to that of a thoracoplasty.

Indication

The indication for air plombage is as follows: (I) the remaining pulmonary parenchyma after resection does not expand and fill the residual pleural space, (II) large raw surfaces of pulmonary parenchyma remain in a plane, which cannot easily contact the chest wall, (III) there is an excessive air leak from the parenchyma (3).

Tips on surgical technique and perioperative management

Portion of the ribs above the pleural space are stripped subperiosteally, leaving attached periosteum on their outer surfaces. The size, shape, and location of the "resultant air pocket" is made to fill the defect left by lung resection. The pleura, periosteum, and intercostal muscles and facia drop into the pleural space and contact the resected surface of pulmonary parenchyma. Pate *et al.* (6) claimed no drainage of this space was done, but we usually place the 19-Fr Blake Silastic Drain® (Ethicon; Somerville, New Jersey, USA) into the pleural space (13). The drainage is under negative pressure of 10 cmH_2O and is removed on postoperative day 14 after confirming no air leak. During this situation, subcutaneous exudate fluid is pooling and the skin develop some swelling in the surgical area. After that, the exudate is absorbed and the surgical skin region become flattering over the course of about 1 month.

A necessary and sufficient air plombage is as follows (6): (I) the volume of the extrapleural pocket is approximately same as the resected pulmonary tissue. (II) The shape of the intrapleural space is approximately similar that of the remaining lung surface.

Care should be taken with regards to the following points (14,15): (I) during operation, avoid creating excessive air pocket. (II) After operation, prevent the "air pocket"

infection. Additionally, the vulnerable ribs due to the loss of periosteal structures develop fractures; therefore, patients should avoid heavy physical exercise and work, and apply the bust band tightly (16). (III) Before operation, draw up the optimal range of "air pocket", avoiding creation of an excessive extrapleural space. Moreover, in late phase after air plombage, the thoracic wall without the intercostal muscles as "supporter" commonly develops atrophic and deformative changes (14). Additionally, the stripped portion of the ribs must be intact to prevent intrapleural contamination of the space with resultant infection (6). To minimize this unfavorable sequela, it is important to avoid dissecting the costal periosteum and intercostal muscles of lower (the 8^{th}–12^{th}) ribs (6).

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