



Dry Pleuroscopy as a Diagnostic Tool for Lung Cancer with Minimal Pleural Effusion

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Abstract

Dry pleuroscopy is a minimally invasive procedure used to evaluate and manage pleural conditions, particularly in cases of minimal pleural effusion (mini-PE) or dry pleural dissemination (DPD). This procedure involves the induction of artificial pneumothorax to create a workspace, allowing for direct access to the pleura without relying on a significant pleural effusion, unlike wet pleuroscopy. The key advantages of dry pleuroscopy include the elimination of the need for general anesthesia, mechanical ventilation, or specialized operating rooms, thereby reducing the risk of complications and associated costs. With a sensitivity of 94.4% and a specificity of 92.8%, dry pleuroscopy is highly effective for diagnosing lung cancer and pleural metastases in cases of minimal effusion. It also aids in lung cancer staging, minimizing the need for invasive procedures like lobectomy in complex cases. Artificial pneumothorax is a key step in dry pleuroscopy. It can be achieved through blunt dissection, optical trocars, or specialized tools such as the Boutin needle or Veress cannula. Ultrasound (USG) guidance further enhances procedural accuracy and safety by reducing complications. Dry pleuroscopy provides a safe, effective, and cost-efficient diagnostic and therapeutic solution, making it preferable to methods such as video-assisted thoracoscopic surgery (VATS), especially in patients unfit for invasive procedures.

Keywords: artificial pneumothorax induction, dry pleuroscopy, lung cancer diagnostics

INTRODUCTION

Pleuroscopy is based on three fundamental principles: induction of artificial pneumothorax, endoscopy, and drainage. This method was first introduced by Hans-Christian Jacobaeus, an internist from Stockholm, Sweden, in 1910. Pleuroscopy was developed as a diagnostic

method and utilizes endoscopy, which has been widely used for visualizing hollow organs. Jacobaeus successfully managed pleural effusion due to tuberculosis infection with pleurolysis and established diagnoses in various cases, including spontaneous pneumothorax, pleural effusion, focal lung disease, and

mediastinal tumors.¹

Although Jacobaeus popularized pleuroscopy, a similar procedure had actually been performed by Francis-Richard Cruise in 1866. This is recorded in the article *Thoracoscopy before Jacobaeus* by Hosck et al in 2002. Before Jacobaeus used the term "thoracoscopy" extensively, it was already recognized in a number of French dictionaries. The first recorded procedure performed by Cruise involved an 11-year-old girl with empyema. The pleuroscopy technique was used to monitor therapy through a fistula connecting the outer skin to the pleura after pleural drainage.¹

Jacobaeus published a summary of his findings that included the staging and etiology of various conditions, including empyema, tuberculous pleuritis, rheumatoid effusion, malignant effusion, parapneumonic effusion, and idiopathic pneumothorax. He distinguished primary from secondary tumors in the lungs, mediastinum, pleura, and chest wall in cancer-related effusions.^{1,2}

As we know, lung cancer was once a rare disease in the early 20th century, but its prevalence has steadily risen over time. It is particularly dangerous due to its poor prognosis, marked by high mortality and morbidity rates, low survival chances, and significant challenges in early detection and screening. This discovery has triggered numerous publications about the advantages of pleuroscopy in various countries. One of the important publications is the *Atlas of Diagnostic Thoracoscopy* by Brandt in 1985. Felix Cova also reviewed the history of diagnostic

thoracoscopy in *Atlas Thoracoscopicon* in 1928.^{1,2}

Recently, dry pleuroscopy has emerged as a key tool for evaluating pleural involvement in lung cancer with minimal effusion. This review outlines its diagnostic value, advantages, and clinical applications.

ANATOMY AND PHYSIOLOGY OF THE PLEURA

The pleura is a serous membrane that lines both lungs. This membrane consists of two layers, namely the outer layer (parietal) and the inner layer (visceral). As the visceral pleura adheres to the lungs, the parietal pleura adheres to the thoracic cavity. The parietal pleura continues its function by separating the lungs from the mediastinal organs, while the visceral pleura follows the fissures between the lung lobes. The pleural recesses are in the anterior and posterior areas, with the parietal pleura in contact with each other without being filled with lung parenchyma. This site is important for pleural fluid accumulation.^{3,4}

The pleura produces serous fluid to fill the space between the pleurae. This fluid ensures that the lungs can move smoothly when expanding and contracting against the chest wall. In addition, pleural fluid keeps both layers of the pleura adhered and prevents the formation of empty spaces with the help of surface tension. The visceral pleura will receive vascularization from the bronchial circulation, while the parietal pleura will be

supplied by the nearby intercostal arteries. The pleura plays an important role in maintaining the effectiveness of lung expansion and contraction. Physiologically, the intrapleural pressure is more negative than the intrapulmonary pressure. This pressure results from forces pulling the visceral pleura away from the chest wall (surface tension and lung elasticity), opposed by the chest wall's elasticity pulling the lungs inward.^{3,4}

Intrapleural fluid serves as the main adhesive agent to maintain negative intrapleural pressure. This condition can be achieved if the amount of pleural fluid does not exceed the maximum capacity of the intrapleural space, the production of fluid is balanced by its removal by the lymphatic system, and there is no air disrupting the adhesion. In pathological conditions, such as pneumothorax due to the entry of air or pleural effusion due to the accumulation of excess fluid, this balance will be disrupted. This imbalance disrupts the ventilation-perfusion ratio.^{3,4}

DEFINITION OF PLEUROSCOPY

Pleuroscopy or thoracoscopy is a procedure to obtain a direct visual image to investigate the pleura. This term is also known as local anesthesia thoracoscopy or medical thoracoscopy. This procedure intentionally induces a pneumothorax to create space for endoscope insertion through an incision in the intercostal space. Pleuroscopy is performed for diagnosis and can also be therapeutic. It can be performed under local or general

anesthesia, with good tolerance and minimal side effects.^{3,5,6}

Pleuroscopy contributes significantly to the establishment of the diagnosis of suspected lung malignancy involving the pleura or originating from the pleura. The picture of effusion may be found, but not always. The examination begins with the cytological analysis of pleural effusion fluid to detect malignant cells. If the result is negative, a closed needle biopsy of the parietal pleura is performed to determine the staging of malignancy.^{1,7}

Pleuroscopy also provides information related to the spread of malignancy, such as involvement of the visceral or parietal pleura, which affects the prognosis. This procedure ensures an accurate diagnosis and helps determine the therapy plan, including surgery, chemotherapy, or palliative therapy. With high accuracy and low risk of complications, pleuroscopy has become the primary method for diagnosing pleural malignancies.^{1,7}

Certain cases were found where the collection of effusion fluid was not possible due to its very small amount, a situation referred to as minimal pleural effusion (mini-PE). This occurs in approximately 25% of lung cancer patients who are not classified as small cell, as well as in up to 80% of pleural metastasis cases.⁸

Pleuroscopy has been established as the gold standard in the diagnosis of suspected malignancy with significant pleural effusion. Its sensitivity approaches that of video-assisted thoracic surgery (VATS), which is 93% (95% CI=91–94%),

with a low complication rate of 2.3% (95% CI=1.9–2.8%).⁸

In cases of minimal or absent effusion, further research is needed, further research is needed to assess the effectiveness and safety of pleuroscopy. This special condition causes the procedure to be known as dry pleuroscopy. Imabayashi et al reported a sensitivity of 94.4%, specificity of 92.8%, PPV of 100%, and NPV of 80% in 18 cases. There is no significant difference in procedure and approach between dry pleuroscopy and wet pleuroscopy in the studies by Imabayashi et al and Joy et al.^{9,10}

CLINICAL APPLICATION OF DRY PLEUROSCOPY

Besides mini-pleural effusion, defined as a small fluid collection adjacent to the primary tumor, there is dry pleural dissemination (DPD), referring to solid pleural metastasis without effusion or with mini-PE <10 mm on CT. The application of dry pleuroscopy achieves an accuracy of 94.4% in determining the staging of non-small cell lung cancer in patients with DPD or mini-PE. Staging errors can reduce treatment effectiveness, with most of these cases classified as M0, even though metastases are often found during surgery. Determining staging solely through radiology also carries the risk of increasing the classification to M1a.^{8,9}

Based on the latest TNM classification, edition 9, pleural effusion, regardless of the extent of extension, is classified as M1a. In certain cases, nodes

that are directly attached to the pleura with mini-PE, as in the study by Joy et al, require dry pleuroscopy to enhance the safety of the biopsy procedure. This approach reduces the risk of lung parenchyma injury due to decreased visibility during the procedure, while also reducing the need for invasive procedures, such as lobectomy, which are often required for extensive lesions. In addition to diagnosing malignancies in the lungs, dry pleuroscopy is also beneficial in identifying the etiology of infections, for example, through biochemical analysis of adenosine deaminase levels in pleural fluid.^{10–16}

Pleuroscopy is a simpler, invasive and more economical option than VATS. Both have a high diagnostic value of around 90 percent, although pleuroscopy sometimes yields less specific results, such as nonspecific pleuritis. VATS is performed by a thoracic surgeon under general anesthesia and mechanical ventilation, whereas pleuroscopy is performed by an interventional pulmonologist under local anesthesia with the patient breathing spontaneously. Choice of procedure depends on the patient's condition, indications, and contraindications.¹⁷ However, extensive pleural adhesions stand as a major contraindication, making the pre-procedural evaluation and determination of the entry site critical.¹⁸

The access locations required for VATS are more numerous compared to pleuroscopy, with three locations for VATS and one or two locations for pleuroscopy. Both techniques can be used for pleural

biopsy, pleurodesis, and pleural inspection.^{1,19}

Pleuroscopy also allows for the direct placement of chest tubes with visual guidance. The VATS approach is more suitable for more invasive procedures, such as lung resection, lung decortication, esophageal surgery, sympathectomy, and pericardial window creation. VATS must be performed in an operating room, whereas pleuroscopy can be performed in an endoscopy suite. The instruments used in VATS are often disposable, and the entire VATS procedure is more complicated compared to pleuroscopy.^{1,19}

TECHNIQUE AND PROCEDURE OF DRY PLEUROSCOPY

Dry pleuroscopy begins with pneumothorax induction, essential in cases with absent or minimal pleural fluid. Various methods are used to create artificial pneumothorax, such as blunt dissection, the use of trocars and cannulas as pleuroscopic access while inducing pneumothorax, and pleura needles. Needle methods, such as the Boutin or Ultra Veress needle, create pleural space for instrument maneuvering while lowering tissue injury risk. The needle is equipped with a manometer to monitor air inflation to ensure adequate space during the procedure.^{19–25}

Blunt dissection is one of the oldest methods used to induce artificial pneumothorax, and the procedure can be assisted with Kelly forceps. The implementation of this method can only

continue if no adhesions between the pleura are found. Mild adhesions can be released with the help of fingers, but if the adhesions cannot be resolved, it is necessary to find another access location or use a different approach. During the procedure, the patient is positioned in the lateral decubitus position to facilitate access. This method is considered simple, but it requires operator experience to reduce the risk of pleural and surrounding tissue injury, with success depending on the access location and the patient's pleural anatomical condition.¹

The insertion of an optical trocar is one alternative for inducing pneumothorax. The trocar serves as an access point for various intervention tools, including optical instruments, to ensure safety by providing adequate visual insight. This method is also important in providing sufficient space for the biopsy instrument to enter and take samples. The use of optical trocars provides an advantage in minimizing the risk of pleural or surrounding tissue injury. This technique requires operator expertise to ensure that the trocar placement is done accurately and safely, especially in cases with complex pleural anatomy.^{12,20}

Artificial pneumothorax can be created by pumping air into the pleural cavity. This process can be performed manually using a 21G needle and a 50 ml syringe, or with a device such as a Veress cannula. Air inflation using the Veress cannula is targeted to reach 800–1000 ml, or until the manometer shows a value of 0 after initially being negative. The Veress cannula requires a sharp incision with

another instrument before it can be inserted, whereas the Boutin needle has two different ends. The pleura is penetrated with the blunt end, and the chest wall is penetrated with the sharp end.^{12,19,20}

The position of the needle is determined through pressure measurement using a manometer to ensure its accurate placement. Although practical, the use of the Boutin needle can increase the risk of bleeding, especially in cases with minimal pleural effusion. As an alternative, there are single-use needles such as the ENDOPATH™ Ultra Veress Insufflation Needle, which is designed to create pneumoperitoneum in laparoscopic surgery and can also be used for pneumothorax induction. This needle is equipped with a blunt stylet safety mechanism based on a spring to reduce the risk of visceral injury, as well as a visual indicator in the form of a red ball that ensures accurate needle placement.^{19,20,26}

By optimizing the quality of lung isolation and deflation within the closed thoracic cavity, good intrathoracic visibility is essential for thoracoscopy success. Double-lumen endotracheal tubes (DL-ETT) are considered the gold standard for lung isolation, as they provide faster and more complete collapse than bronchial blockers (BB). By ventilating one lung while deflating the other, one-lung ventilation (OLV) provides optimal pleural visualization while maintaining oxygenation.^{27–29}

After the artificial pneumothorax is formed, a pleuroscope is inserted to trace

and examine the condition of the pleura. If there are indications for a biopsy, representative tissue is taken and stored in a container with a preservative, such as formalin, for further examination. During the examination, the condition of the pleura is thoroughly assessed to detect any abnormalities or disease spread. After completion, all instruments, including the access used, were removed, and the procedure continued with the insertion of a double-lumen chest tube sized Fr 20–24 for the drainage process and patient recovery.^{1,22}

THE ROLE OF ULTRASOUND IN THE INDUCTION OF ARTIFICIAL PNEUMOTHORAX

Imaging guidance, such as ultrasound (USG), can reduce the risk of complications during pleuroscopy procedures. One study showed a 19% reduction in the risk of pneumothorax. Ultrasound can be more sensitive than a chest X-ray in identifying pleural effusion.^{25,30}

Additionally, ultrasound improves procedural safety and reduces the need for additional invasive procedures in pleural evaluation. Ultrasound can predict the presence of fibrous septa in the pleura, providing an additional advantage. The pleuroscopy approach with ultrasound guidance compared to artificial pneumothorax induction did not show a statistically significant difference in terms of complications, although the number of complications in the artificial

pneumothorax induction was higher (7.6% compared to 6.2%).^{25,30}

In a study using ultrasound guidance for the induction of artificial pneumothorax followed by pleuroscopy, 77 patients were involved, and 67 procedures (87%) were successfully performed. Histopathological results showed chronic pleuritis in 58.2% of cases and mesothelioma in 16.4% of cases. No adverse effects were found during the procedure.^{18,31}

The use of ultrasound can identify the presence of pneumothorax in the pleural space. In normal conditions, the two pleura that meet and rub against each other produce a lung sliding image that moves in sync with the heartbeat (lung pulse) on the ultrasound. In M-mode ultrasound, this image resembles a seashore pattern, with a rough texture due to lung sliding. In the case of pneumothorax, the separation of the two pleural layers eliminates lung sliding and lung pulse, resulting in a horizontal image that consistently forms a barcode or stratosphere pattern.^{18,31}

CONCLUSION

Dry pleuroscopy is a valuable diagnostic approach for patients with minimal or no pleural effusion, especially when imaging is inconclusive. It enables direct visualization and biopsy of pleural lesions, improving diagnostic accuracy and treatment decisions. Ultrasound guidance and proper technique enhance safety and effectiveness. Further research is needed

to refine the technique and assess less invasive alternatives.

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