

A Case of Pulmonary Bulla Volume Reduction by Transbronchial Puncture Under Electromagnetic Navigation Platform Combined With O-Arm CT Guidance

Jing Zhu^{1,2}, Xiaoxiao Xu^{1,2}, Rujuan Wang^{1,2}, Zhenhua Li^{1,2}, Ying Wang^{1,2}, Yi Hu¹

¹Department of Pulmonary and Critical Care Medicine, The Central Hospital of Wuhan, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, People's Republic of China; ²Wuhan Clinical Research Center for Interventional Diagnosis and Treatment of Respiratory Diseases, Hubei, People's Republic of China

Correspondence: Yi Hu, Department of Pulmonary and Critical Care Medicine, The Central Hospital of Wuhan, Tongji Medical College, Huazhong University of Science and Technology, 26 Shengli Street, Wuhan, 430014, People's Republic of China, Tel +86-13995618974, Email huyi@zxhospital.com

Abstract: Pulmonary bullae are a common complication of chronic obstructive pulmonary disease (COPD), but treatment options are limited for patients with poor lung function and giant emphysematous bullae (GEB). We reported a case of a 61-year-old female with severe COPD complicated by a newly developed GEB. Using electromagnetic navigation technology, we precisely located and targeted the bronchi adjacent to the bullae within the lung. Guided by O-arm CT imaging, we punctured the bullae with a biopsy needle, evacuated the air, and administered autologous blood and thrombin. A follow-up pulmonary CT scan three days post-procedure revealed a significant reduction in the size of the giant bulla. Additionally, the patient's wheezing symptoms improved, and her performance on the 6-minute walk test showed some enhancement.

Keywords: pulmonary bulla, chronic obstructive pulmonary disease, bronchoscope, bronchoscopic lung volume reduction

Introduction

A pulmonary bulla is a thin-walled, air-filled sac greater than 1 cm in diameter, formed due to increased alveolar pressure and subsequent destruction of the alveolar septa.¹ When these bullae enlarge into giant pulmonary bullae, they can compress surrounding normal lung tissue, exacerbating the already impaired lung function in COPD patients. This can lead to increased breathlessness, respiratory failure, and potentially life-threatening complications.² The current incidence of COPD with giant bullae remains unknown. While conventional thoracoscopic surgery is commonly used to resect large bullae, pulmonary volume reduction can also be achieved through less invasive techniques such as endobronchial valves (EBV) and autologous blood injection.³ We report a case in which a large bulla was successfully treated by percutaneous puncture via bronchoscopy, air drainage, and autologous blood injection, guided by an electromagnetic navigation platform and O-arm CT imaging.

Case Presentation

The patient, a 61-year-old retired woman with a history of recurrent cough and wheezing for over three years had worsened in the past month. She had been diagnosed with chronic obstructive pulmonary disease (COPD) more than three years prior and was on long-term inhalation therapy (flutimevir inhalation powder 100 µg: 62.5 µg: 25 µg, Glaxo Operations UK Ltd) at a dose of one inhalation per day. The patient had also experienced a left-sided spontaneous pneumothorax in 2018. She had a 30-year history of smoking, averaging 20 cigarettes per day, but had been smoke-free for three months. There was no history of infectious diseases or family history of malignant tumors.

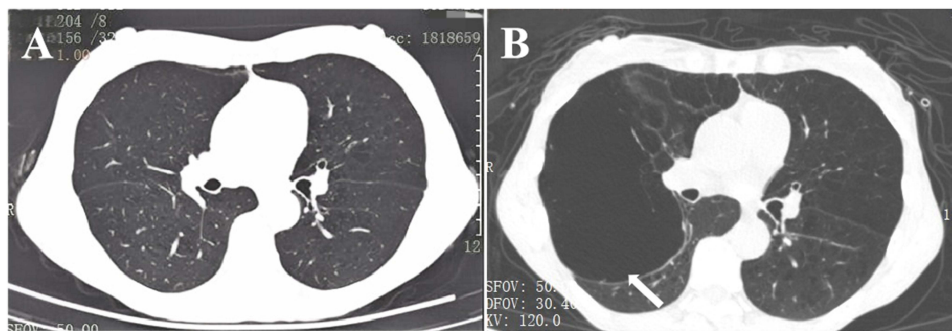


Figure 1 Comparison of the patient's lung CT at different time. **(A)** The patient's lung CT from two years ago did not show pulmonary bulla. **(B)** The arrow points to a newly developed pulmonary bulla.

The patient presented with a recent onset of cough, producing white sputum, which was worse at night and accompanied by dyspnea on exertion. Upon admission, her symptoms had progressed to worsening dyspnea and respiratory distress, requiring her to maintain an upright position to breathe. Her oxygen saturation was 90% on 2L/min oxygen supplementation, and arterial blood gas analysis revealed a pH of 7.31, PO₂ of 67 mmHg, and PCO₂ of 82 mmHg. She was subsequently transferred to the Respiratory Intensive Care Unit (RICU), where she received high-flow oxygen, corticosteroids, antibiotics, and bronchodilators, leading to an improvement in her wheezing symptoms.

Laboratory tests revealed an elevated eosinophil percentage of 9.40% (reference range: 0.4–8) and an increased basophil percentage of 2.20% (reference range: 0–1), while other parameters were within normal limits. No significant abnormalities were detected in other blood biochemistry and indicators. During hospitalization, a high-resolution CT scan of the lungs revealed a new pulmonary bulla measuring 121 mm in diameter, compared to a previous CT scan conducted two years earlier (Figure 1). After the patient's condition stabilized, pulmonary function tests showed an FEV₁ of 0.74L, FVC of 1.61L, and an FEV₁/FVC ratio of 46.15%. The patient's mMRC grade was assessed as 3, and her six-minute walk distance was measured at 330 meters. We informed the patient about the methods and risks associated with managing pulmonary bulla. The patient, who strongly rejected surgery and considered EBV surgery expensive, agreed to participate in our study and signed an informed consent form.

The Process of Diminishing the Size of Pulmonary Bullae

Path Design

The thin-slice lung CT scan was imported into the navigation path planning system (Lungcare-Electromagnetic Navigation Bronchoscopy, China) for preoperative planning (Supplementary Figure 1A). During the procedure, under general anesthesia and guided by electromagnetic navigation using a bronchoscope (EB19-J10, Pentax Corporation, Japan), the target bronchus adjacent to the bulla was successfully accessed.

Investigate and Identify Pulmonary Bullae

A disposable biopsy aspiration needle (BC1418, Biotechnology Co., Ltd., China) was guided along the predetermined path to access the target bronchus (Supplementary Figure 1B). The O-arm CT (Supero-O71, First Imaging Medical Equipment Co., Ltd., China) was used to precisely locate the needle near the bulla, ensuring accurate penetration. The O-arm CT was then employed to confirm the optimal positioning of the needle (Figure 2).

Suction and Injection of Autologous Blood

After removing the needle core, a three-way connector and a 50 mL syringe were used to withdraw a total of 1500 mL of gas, reducing the size of the bulla from 11.33 cm × 7.53 cm to 8.0 cm × 6.1 cm. Subsequently, 60 mL of autologous blood and 1U of thrombin (Zhongke Pharmaceutical Co., Ltd., China) were injected into the bulla. The presence of autologous blood within the bulla was confirmed using O-arm CT.

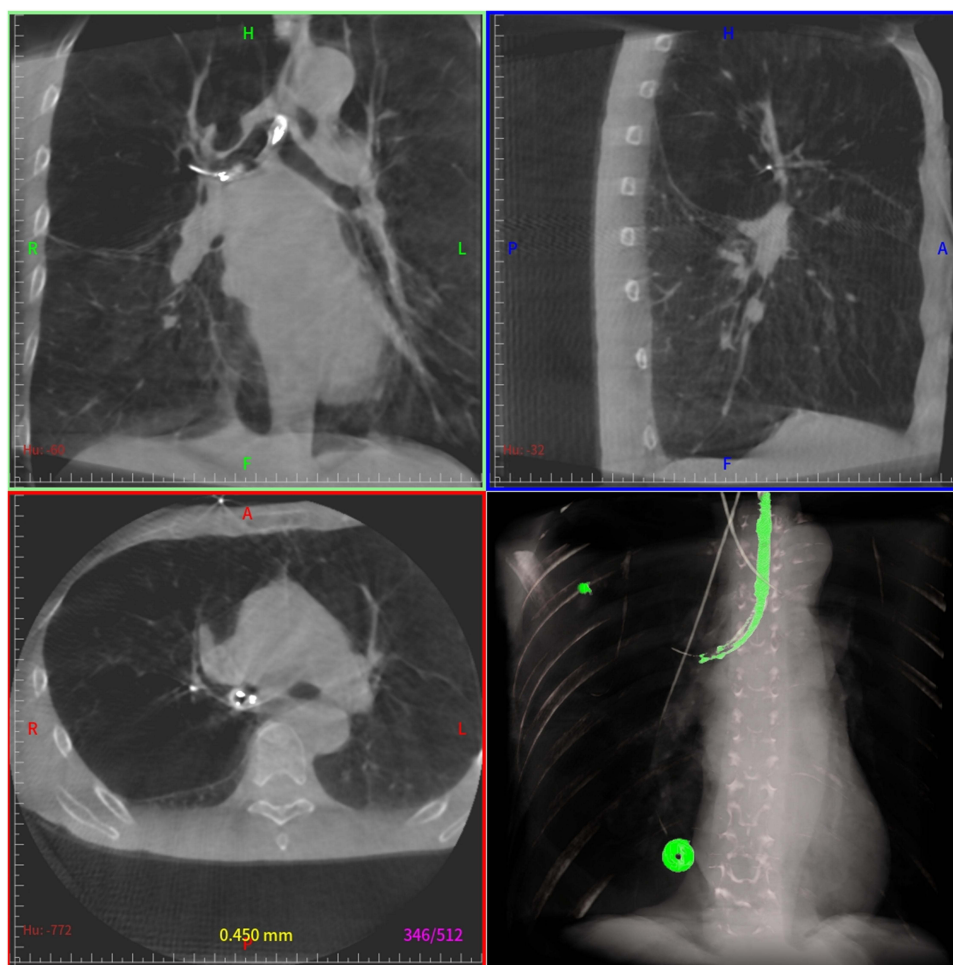


Figure 2 Real-time O-arm CT scan showing the position of the puncture needle at different levels and its relation to the pulmonary bulla.

Observation of Therapeutic Effects

After the procedure, the patient's dyspnea symptoms significantly ameliorated, and a follow-up lung CT scan three days later revealed a marked reduction in the size of the bulla compared to pre-procedure (Figure 3 and [Supplementary Figure 2](#)). Additionally, improvements were observed in the six-minute walk test, dyspnea index, and pulmonary function one month after discharge (Table 1). The patient continued to receive regular follow-up and management.

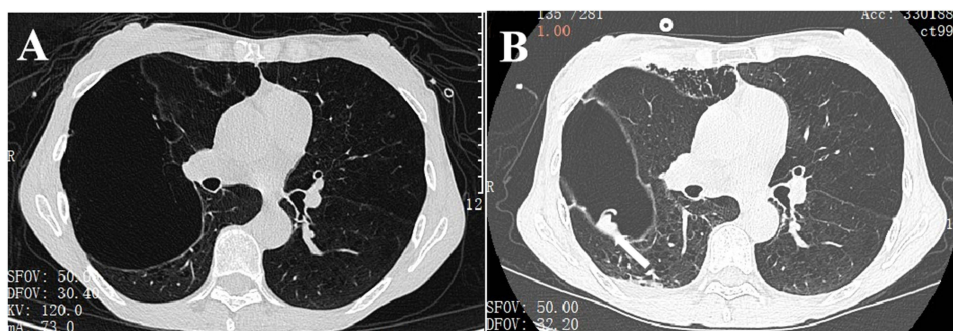


Figure 3 Imaging changes of the pulmonary bulla before and after treatment. (A) The size of the pulmonary bulla is 11.33cm×7.53cm. (B) The size of the pulmonary bulla reduced to 8.0cm×6.1cm, with partial filling of the bulla by autologous blood (indicated by the arrow).

Table 1 Evaluation of the Effectiveness of Treatment for Pulmonary Bullae

Characteristic	Pre-Treatment	Post-Treatment*
Size of the bullae (mm)	121×79×53	113×78×43
FVC (L)	1.61	1.72
FEV ₁ (L)	0.74	0.9
FEV ₁ /FVC%	46.15	52.42
mMRC dyspnoea scale	3	2
Six-minute walking test (m)	330	463

Notes: * means one month later.

Abbreviations: FVC=forced vital capacity; FEV₁=forced expiratory volume in the first second; mMRC=modified Medical Research Council.

Discussion

The etiology and pathogenesis of pulmonary bullae remain unclear. However, previous studies have identified several factors associated with the development of pulmonary bullae, including smoking, alpha-1 antitrypsin deficiency, intravenous drug use, and the consumption of marijuana, cocaine, and, more recently, COVID-19.⁴⁻⁶ In this case of rapid progression of pulmonary bullae in a patient with COPD, the extensive history of smoking is likely a significant contributing factor.

Large bullae in the lungs can significantly impact lung function, especially in COPD patients, exacerbating wheezing symptoms and reducing quality of life. Traditionally, surgical thoroscopic methods have been employed to remove large bullae. However, for patients with an FEV₁ of less than 35% of the predicted value, severe diffusion impairment, hypoxemia, and hypercapnia, postoperative functional recovery is often unsatisfactory, even after bullae resection.⁷ In cases of severe COPD, we concluded that the patient are unlikely to benefit from surgical resection. Instead, endobronchial respiratory interventional techniques may offer a safer alternative, as determined through multidisciplinary discussion.

In 2006, Noppen et al reported the first successful case of treating a symptomatic, gradually enlarging left lower lobe bulla by placing four endobronchial valves (EBVs) in the left lower lobe bronchus via endobronchial ultrasound.⁸ In 2008, Kanoh et al pioneered the use of endobronchial tubes to deliver autologous blood with thrombin as a treatment for giant emphysematous bullae (GEB) in the lungs. Both techniques resulted in a significant reduction in bullae size, leading to marked improvements in lung function and quality of life.⁹ However, these approaches require the identification of the target bronchi supplying the bullae. In COPD patients with large bullae, these structures may compress and distort the bronchi responsible for ventilation, making it challenging to identify the correct bronchi.

Furthermore, successful EBV treatment necessitates an intact lobar fissure and absence of collateral ventilation—criteria that only a small proportion of COPD patients meet.¹⁰ In this study, we employed electromagnetic navigation technology for the first time to accurately identify the primary target bronchi leading to or adjacent to the pulmonary bullae. A needle was then inserted directly through the bronchial wall into the bullae for aspiration lung decompression, followed by the injection of autologous blood and thrombin to fill the bullae. Notably, collateral ventilation was not considered to reduce procedural complexity and enhance efficacy. The procedure resulted in a significant reduction in the patient's bulla volume and improvement in dyspnea symptoms. This novel treatment approach, combining physical reduction with an autologous blood patch, is relatively straightforward and demonstrates comparable efficacy to EBV lung reduction, with a potentially improved safety profile as evidenced by the absence of complications. The improvement in dyspnea symptoms may be attributed to the decompression of normal lung tissue following bulla reduction, leading to enhanced respiratory function. Research by Huh et al also demonstrated that reducing bulla volume is an independent prognostic factor for survival in COPD patients, significantly enhancing pulmonary function.¹¹ The potential rebound in bulla volume post-treatment may depend on the presence of collateral ventilation and the absorption and degradation of autologous blood within the bullae. While the patient has shown temporary improvements in lung function and dyspnea index, long-term benefits and deceleration of lung function decline are still under long-term observation.

This case of pulmonary bullae was successfully treated, but patient selection is crucial for the success of this method. Several factors and precautions must be considered: 1) The location of the pulmonary bulla (accessibility for bronchoscope and puncture

needle), the thickness of the bulla wall (needle penetrability), and its relationship with adjacent bronchi (ideally a segmental bronchus or higher for easier vertical needle insertion). 2) Real-time imaging techniques, such as cone-beam computed tomography, should be employed during the procedure to continuously monitor needle positioning and detect potential complications. 3) The amount of autologous blood injected into the bullae lacks a standardized protocol and may depend on the size of the bullae.

In conclusion, the integration of an electromagnetic navigation platform with O-arm CT guidance for transbronchial puncture and lung reduction of bullae appears to be a promising and potentially safe and effective approach. However, further validation is required through larger-scale studies involving more participants with bullae.

Ethics and Consent Statement

The authors confirm that the patient provides written informed consent and gives her consent for images and all other clinical information to be published. The ethic approval is not required to publish these case report details according to the institutional ethic committee.

Funding

This work was supported by National Natural Science Foundation of China (project number: 62073149) and The Funding for Scientific Research Projects from Wuhan Municipal Health Commission (project number: WX23A81).

Disclosure

The authors declare that they have no conflicts of interest in this work.

References

- Sharma N, Justaniah AM, Kanne JP, Gurney JW, Mohammed TL. Vanishing lung syndrome (giant bullous emphysema): CT findings in 7 patients and a literature review. *J Thoracic Imaging*. 2009;24(3):227–230. doi:10.1097/RTI.0b013e31819b9f2a
- Marchetti N, Criner GJ. Surgical Approaches to Treating Emphysema: lung Volume Reduction Surgery, Bullectomy, and Lung Transplantation. *Semin Resp Crit Care Med*. 2015;36(04):592–608. doi:10.1055/s-0035-1556064
- Zhu J, Yin W, Xiao Y, Yuan ML, Ni F, Hu Y. Application of interventional respiratory techniques in the treatment of pulmonary bullae: an update. *Chin J Tubercul Respirat Dis*. 2024;47(3):259–264. doi:10.3760/cma.j.cn112147-20230902-00129
- Ghatts C, Barreiro TJ, Gemmel DJ. Giant bullae emphysema. *Lung*. 2013;191(5):573–574. doi:10.1007/s00408-013-9495-z
- Davies P, Bradley C. Vanishing lung syndrome: giant bullous emphysema. *Lancet*. 2017;390(10112):2583. doi:10.1016/S0140-6736(17)32246-8
- Petroncini M, Valentini L, Solli P, Bertoglio P. Giant lung bulla as a late-onset complication of mild SARS-CoV-2 pneumonia. *Monaldi Arch Chest Disease*. 2023. doi:10.4081/monaldi.2023.2559
- Nakahara K, Nakaoka K, Ohno K, et al. Functional indications for bullectomy of giant bulla. *Ann Thorac Surg*. 1983;35(5):480–487. doi:10.1016/S0003-4975(10)60419-5
- Noppen M, Tellings JC, Dekeukeleire T, et al. Successful treatment of a giant emphysematous bulla by bronchoscopic placement of endobronchial valves. *Chest*. 2006;130(5):1563–1565. doi:10.1378/chest.130.5.1563
- Kanoh S, Kobayashi H, Motoyoshi K. Intrabullous blood injection for lung volume reduction. *Thorax*. 2008;63(6):564–565. doi:10.1136/thx.2007.087957
- Klooster K, ten Hacken NH, Hartman JE, Kerstjens HA, van Rikxoort EM, Slebos DJ. Endobronchial Valves for Emphysema without Interlobar Collateral Ventilation. *New Engl J Med*. 2015;373(24):2325–2335. doi:10.1056/NEJMoa1507807
- Huh JY, Jeong BH, Yoon HI, et al. Endobronchial valves for emphysema and persistent air-leak: 10-year experience in an Asian country. *BMC Pulm Med*. 2024;24(1):162. doi:10.1186/s12890-024-02982-2

International Journal of Chronic Obstructive Pulmonary Disease

Publish your work in this journal

The International Journal of COPD is an international, peer-reviewed journal of therapeutics and pharmacology focusing on concise rapid reporting of clinical studies and reviews in COPD. Special focus is given to the pathophysiological processes underlying the disease, intervention programs, patient focused education, and self management protocols. This journal is indexed on PubMed Central, MedLine and CAS. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/international-journal-of-chronic-obstructive-pulmonary-disease-journal>

Dovepress
Taylor & Francis Group