

Recovery of temperature to normal may indicate the best time for surgery in patients with lung cancer complicated by a lung abscess: A case report

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Abstract. In clinical practice, the management of a lung abscess (LA) usually initiates with antibiotic administration to address the infection. Nevertheless, for cases presenting with refractory pulmonary tumors complicated by a LA, surgical intervention stands as an essential therapeutic recourse. The current study presents case involving lung cancer complicated by a LA. Despite continuously elevated infection marker levels, surgical intervention was promptly performed following the normalization of the patient's temperature. Subsequent postoperative histopathological analysis and immunohistochemistry revealed a moderately differentiated squamous cell carcinoma located in the lower right lung, classified as T2aN0M0, Ib stage. Following a 2-year follow-up period, no cancer recurrence was observed and the patient exhibited a favorable prognosis. This case highlights the vital role of surgical timing in the management of lung cancer complicated by an acute LA. Early surgical intervention may play a crucial role in arresting the advancement of lung cancer, indicating that prompt surgery upon temperature normalization could serve as a significant treatment indication for these patients.

Introduction

A lung abscess (LA) represents a serious respiratory infectious condition marked by elevated occurrence and fatality rates. Despite the introduction of antibiotic therapy, the mortality rate of lung abscesses remains high at 10-20% (1).

Furthermore, a recent study indicated that the mortality rate of patients with lung abscesses in the intensive care unit may reach up to 52% (2). LAs present as necrotic lesions within the lung parenchyma, induced by microorganisms, resulting in the development of abscess cavities containing necrotic or liquefied substances, frequently exhibiting a liquid-gas level (3). With continuous progress in the clinical utilization of antibiotics, a significant portion of LA cases can be efficiently managed. Nevertheless, in cases of LAs showing resistance to conservative therapies, surgical intervention remains imperative. Large-scale prospective investigations are warranted to establish evidence-based protocols for surgical and antibiotic interventions (4).

In recent years, the occurrence of lung cancer combined with LA has been rising in clinical settings. A study examining the clinical features of 222 patients with LA revealed that 7% presented with coexisting pulmonary malignancies (5). Subsequent investigations suggest that tumor-related immunosuppressive signaling and impaired immune function could exacerbate bacterial infections in the presence of tumors, thereby escalating the seriousness of LAs (6). Hence, the concomitance of LA and lung cancer warrants substantial consideration. The combination of LA and lung cancer poses an increased risk of therapeutic inefficacy and postoperative mortality attributed to the complexities in surgical scheduling, thereby exerting notable detrimental impacts on patient outcomes (7). Conversely, in the diagnosis and management of this condition, the sudden emergence of LAs may overshadow the identification and treatment of primary lung cancer, potentially leading to diagnostic errors, oversight and subsequent treatment delays for lung cancer (8). Moreover, the presence of LAs markedly heightens the likelihood of postoperative infections subsequent to lung cancer therapy (9), presenting notable complexities for clinicians in treatment strategizing and surgical scheduling.

Fever is a physiological response to infection, commonly associated with the activation of the immune system, signifying its effort to combat pathogens (10). However, surgical procedures can temporarily compromise immune function, thereby increasing the patient's susceptibility to infections (10). Moreover, fever can influence the metabolism and distribution

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of drugs, potentially complicating anesthesia management and thereby affecting the overall effectiveness of the surgery (11). For patients with lung cancer, concurrent acute LAs and a history of fever, scheduling surgery soon after the body temperature has normalized may be a more appropriate approach than continuing conservative treatment with antibiotics. The objective of the present case report is to provide insights into the diagnosis and management of these conditions, and to offer practical guidance for clinical application.

Case report

A 64-year-old male patient exhibited blood-tinged sputum of unknown etiology in April 2022. The blood appeared bright red, with an estimated volume of ~5 ml, and no systematic intervention was administered. Subsequently, in May, the patient encountered a recurring episode of hemoptysis with similar attributes and volume, prompting the performance of a chest computed tomography (CT) scan at Xingyi People's Hospital (Xingyi, China). The imaging examination identified a lesion in the posterior segment of the right lower lobe, accompanied by slight bronchial dilation and distal infection, measuring ~2.8x3.2 cm (Fig. 1A and B). Despite the administration of antitussive (10 mg codeine, taken orally twice daily), hemostatic (10 units posterior pituitary hormone dissolved in 250 ml 10% glucose solution for intravenous infusion) and anti-infective therapies (1.5 g cefuroxime sodium in 100 ml 0.9% sodium chloride solution administered via intravenous infusion, once every 8 h), the patient's clinical status did not demonstrate any notable improvement.

At 6 days post-recurrence of hemoptysis, the patient was transferred to the Affiliated Hospital of Guizhou Medical University (Guiyang, China) for additional evaluation and management. The patient had a clean medical record, devoid of prior medical conditions or notable medical history. The patient had a smoking history of >40 years, consuming ~15 cigarettes daily, and had abstained from smoking for 1 week. Upon admission, a focused physical examination revealed diminished breath sounds on the right side, without any additional notable findings. Diagnostic workup: Throughout the hospitalization, a series of blood cell evaluations were performed, and the inflammatory marker results, including white blood cells (normal value, $3.5\text{--}9.5 \times 10^9/\text{l}$), absolute neutrophils (normal value, $1.8\text{--}6.3 \times 10^9/\text{l}$) and neutrophil percentage (normal range, 40–75%), which were higher than normal before surgery, are presented in Table I. Coagulation parameters, pulmonary function tests, whole-body bone scintigraphy and cranial CT findings all exhibited normal results. The chest CT scan exhibited patchy opacities in the right lower lobe with the presence of a cavity, measuring ~5.7x4.5 cm (Fig. 1C and D). Following imaging assessments, the observed lesion was suspected to be indicative of lung cancer. At 2 days post-admission, the patient developed a high fever, with a maximum temperature reaching 39.2°C. Empirical antibiotic therapy with cefuroxime sodium was initiated (1.5 g cefuroxime sodium in 100 ml 0.9% sodium chloride solution administered via intravenous infusion, once every 8 h). From day 3 post-admission, the treatment was switched to piperacillin for infection control (4.5 g piperacillin sodium in 100 ml 0.9% sodium chloride solution administered via intravenous infusion, once every 8 h), but the

fever persisted and the temperature did not return to normal. On day 3 post-admission, the patient underwent bronchoscopy procedures, during which biopsies were obtained from the middle right bronchus and the posterior segment of the right lower lobe; however, the findings did not definitively establish a diagnosis of lung cancer (Fig. 2). On the day 6 post-admission, meropenem was introduced (1 g meropenem sodium in 100 ml 0.9% sodium chloride solution administered via intravenous infusion, once every 8 h), leading to gradual temperature control and stabilization at normal levels. The sputum culture and sensitivity test results on the day 11 post-admission revealed that the *Klebsiella pneumoniae* strain causing the infection was resistant to amoxicillin and cefuroxime sodium, but sensitive to levofloxacin, imipenem and meropenem. This explains why the fever gradually came under control after switching to meropenem.

Despite the inconclusive outcomes of the bronchoscopy, a thorough assessment of the patient's medical history involving blood-tinged sputum and chest CT results indicated a strong likelihood of lung cancer, potentially complicated by a secondary acute LA attributed to bronchial obstruction by the tumor. A follow-up chest CT scan 8 days later demonstrated a decrease in the lesion size within the right lower lobe relative to the previous imaging assessment (Fig. 3). However, the full blood count conducted after another 2 days revealed an elevated white blood cell count $20.99 \times 10^9/\text{l}$ (normal value $3.5\text{--}9.5 \times 10^9/\text{l}$), neutrophil count $18.72 \times 10^9/\text{l}$ (normal value $1.8\text{--}6.3 \times 10^9/\text{l}$) and neutrophil percentage 89.20% (normal range 40–75%), suggesting inadequate control of the infection. After the patient's temperature normalized, surgical intervention was scheduled to remove the lesion in a timely manner. The patient underwent video-assisted thoracoscopic surgery involving a right lower lobectomy, decortication and systematic lymph node dissection under anesthesia. Subsequent histopathological and immunohistochemical analyses (Data S1; Table S1) verified the presence of moderately differentiated squamous cell carcinoma in the right lower lobe (Fig. 4). The tumor cells were cytokeratin (CK)(+), epithelial membrane antigen (partially +), vimentin(-), CK7(-), p63(+), p40(+), CK5/6(+), CK20(-), thyroid transcription factor-1(-), napsin A(-), CD56(-), synaptophysin(-), chromogranin A(-) and Ki-67(+; ~80%). Notably, all examined lymph nodes were negative, and the tumor exhibited dimensions of 4x3 cm without evidence of distant metastasis. Consequently, according to the Tumor-Node-Metastasis staging system for Non-Small Cell Lung Cancer (NSCLC) in the 8th edition the tumor was determined as T2aN0M0, Ib (12).

Within 4 days of surgery, the patient received levofloxacin at a dose of 0.2 g in 250 ml 0.9% sodium chloride solution administered via intravenous infusion, twice a day. Reexamination revealed that infection markers were stable and had returned to normal, while the symptoms of cough and hemoptysis gradually subsided. Apart from fat liquefaction at the surgical site, no other complications were reported in the postoperative period. The patient was diagnosed with early stage squamous cell carcinoma, and no adjuvant antineoplastic treatment was prescribed following the surgical procedure. Subsequent to the intervention, the postoperative chest CT scan, depicted in Fig. 5, exhibited no notable abnormalities. Regular follow-up assessments were conducted post-discharge, including chest

Table I. Statistical table of inflammation-related indices in blood cell analysis examination.

Date post-admission	White blood cells, $\times 10^9/l$ (normal value, $3.5-9.5 \times 10^9/l$)	Absolute neutrophils, $\times 10^9/l$ (normal value, $1.8-6.3 \times 10^9/l$)	Neutrophil percentage (normal range, $40.00-75.00\%$)
Day 1	16.64	13.07	78.40
Day 4	23.69	21.34	90.00
Day 8	18.57	15.90	85.60
Day 11	18.60	15.80	84.90
Day 14	20.99	18.72	89.20
Day 17	10.98	8.80	80.10
Day 22	4.63	3.23	69.70
Day 24	5.13	3.42	66.70
Day 28	9.64	7.21	74.80

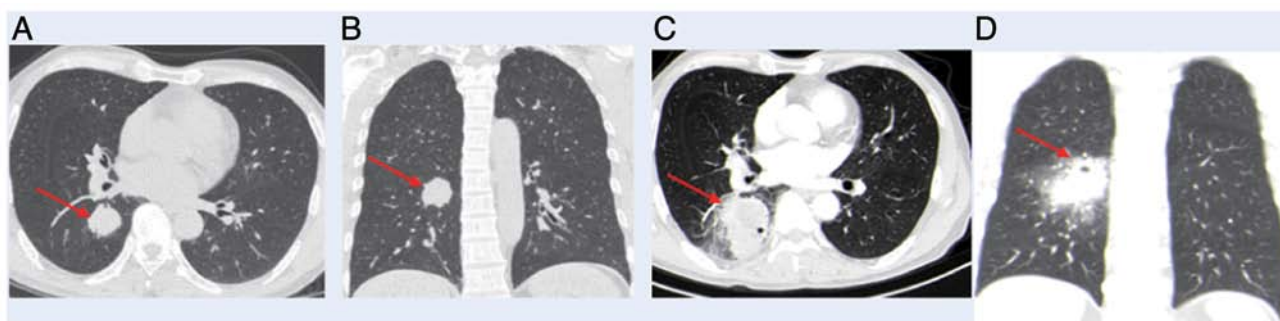


Figure 1. Results of chest CT examination. (A and B) Images at 5 days pre-admission. (A) Axial and (B) coronal CT scans of the chest, and the red arrow indicates a mass in the right lower lung. (C and D) Images at 1 day post-admission. (A) Axial and (B) coronal CT scans of the chest, and the red arrow indicates a right lower lung patch with cavitation. Lung cancer was suspected and infectious lesions complicated with abscess formation could not be ruled out. CT, computed tomography.

CT scans every 3 months, all of which demonstrated no significant abnormalities. By the time of the follow-up chest CT in March 2024, the patient had shown substantial recovery.

Discussion

The present study describes a case of lung cancer complicated by an acute LA. Advancements in medical technology and public health awareness, notably through low-dose CT screening for high-risk lung cancer populations, have led to the simultaneous detection of lung infections. This early identification enables prompt treatment interventions to prevent the escalation of complications (13,14). However, in clinical practice, primary lung tumors can be missed due to the presence of LAs, potentially resulting in misdiagnosis as benign LAs. Furthermore, malignant LAs exhibit clinical and radiographic characteristics akin to those of benign LAs, thereby presenting substantial obstacles in the diagnosis and treatment of lung cancer complicated by LA (15). Therefore, it is essential to differentiate between these conditions before establishing a definitive pathological diagnosis. In pulmonary cryptococcosis, chest X-rays commonly reveal lung masses predominantly situated in the lower lobes, accompanied by indications of parenchymal consolidation and diffuse interstitial infiltration (16-18). The radiographic characteristics of pulmonary actinomycosis may encompass

atelectasis and cavitation; however, it typically manifests as multiple, indistinct nodules or mass-like shadows (19). LAs resulting from aspergillomas exhibit radiographic similarities to malignant tumors, featuring a distinct mass within the cavity; they can be identified by the presence of thick-walled, round or oval cavities (20). Therefore, in individuals presenting with LAs, maintaining vigilance for potential concurrent lung cancer is essential to prevent overlooking the optimal treatment window, which could detrimentally impact prognosis (7).

The treatment of lung cancer complicated by acute LA centers on efficiently tackling both the infection stemming from the LA and the prompt handling of the primary lung tumor. Benign LAs are usually responsive to antibiotic therapy or percutaneous drainage, with surgical intervention being uncommon (7,21). Nevertheless, in cases of lung cancer accompanied by LA, conservative treatment alone may prove inadequate in addressing the condition. Abscesses developed within the tumor pose challenges in effectively managing infections through antibiotic therapy (22), and the effectiveness of percutaneous drainage for abscesses linked to malignant tumors is limited (7). Conversely, as lung cancer advances, relying solely on conservative management for LAs may lead to missing the opportune treatment window for lung cancer. Currently, there is a lack of definitive guidelines for managing lung cancer complicated by LA. Previous studies suggest an

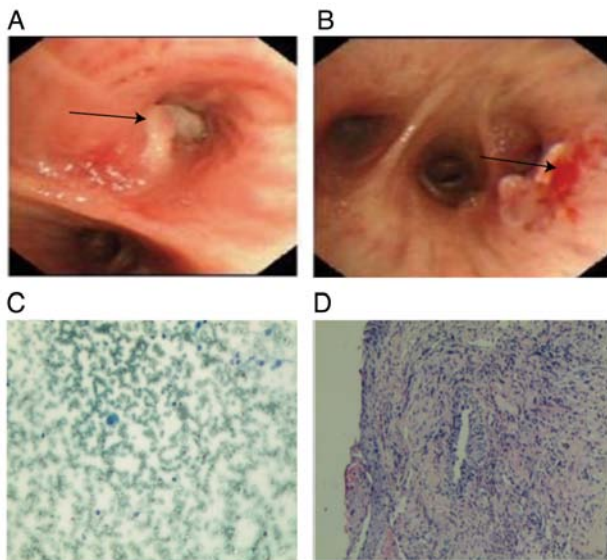


Figure 2. Fiberoptic bronchoscopy at 3 days post-admission. (A) Mucosal uplift and nodular changes were seen in the posterior wall of the lower lobe of the right lung. (B) A neoplasm was found at the opening of the dorsal segment of the right lower lobe with luminal stenosis and mucosal swelling. (C) Pathological images of Papanicolaou staining method at x200 magnification. Pathological biopsy of the distal middle segment of the right bronchus and the dorsal segment of the lower lobe of the right lung revealed chronic inflammation of the bronchial mucosa, with squamous metaplasia and focal squamous epithelial mild-to-moderate atypia. (D) Pathological images of H&E staining at x200 magnification. Bronchial brushing cytology showed a large number of red blood cells, numerous ciliated columnar cells and a small number of atypical cells.

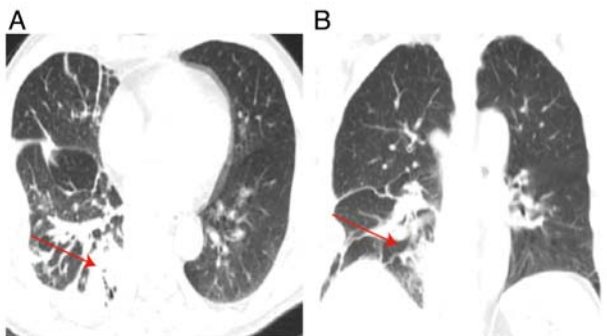


Figure 3. Results of chest CT examination at 11 days post-admission. (A) Axial and (B) coronal CT scans of the chest. In the right lung, there were patchy lesions with cavitation in the lower lobe (red arrow), and the extent of the lung infection was less than before. Multiple infection lesions and partial consolidation in the middle and lower lobe of the right lung were less extensive than before. CT, computed tomography.

initial approach involving anti-infective therapy followed by subsequent anticancer treatment once the infection is fully controlled (8,23). Nonetheless, the presence of concurrent lung cancer prolongs the duration required to manage the infection, yielding suboptimal outcomes. The clinical rationale of deferring lung cancer treatment until full resolution of pulmonary infection appears compelling. Hence, early surgical intervention following diagnosis or during a high suspicion scenario may represent a viable new treatment approach for lung cancer accompanied by pulmonary abscess.

Determining the optimal timing for surgery in cases of lung cancer complicated by LA is a topic deserving further

investigation. Studies suggest that patients exhibiting relatively stable vital signs also demonstrate a favorable prognosis (24). Delaying surgery until vital signs stabilize while the primary lung tumor advances may lead to missed optimal surgical timing in lung cancer cases, attributable to hesitancy. Thus, the primary focus is on actively managing the patient's temperature and infection indicators, enhancing overall patient condition, and conducting surgery under optimal circumstances. Even in individuals with advanced non-small cell lung cancer complicated by LA, a favorable prognosis can be attained through thorough preoperative preparation and judicious selection of the surgical timing (25). The diagnostic and treatment timelines of the present case are illustrated in Fig. 6.

Throughout the hospitalization period, the patient presented with a sustained high fever, with initial assessments indicating potential inadequacy in infection management with the broad-spectrum antibiotic cefuroxime sodium, alongside complications stemming from the coexistence of lung cancer and an LA. Research has indicated that the combination of a tumor complicated by an LA, coupled with pathogen resistance to antibiotics, represents the primary factor contributing to the ineffectiveness of conservative antibiotic therapy for LAs (26). At 11 days post-admission, sputum bacterial culture and susceptibility testing revealed that the patient's *Serratia marcescens* infection was resistant to amoxicillin, cefuroxime and cefotaxime, while being susceptible to ceftriaxone, ceftazidime, levofloxacin, imipenem, and meropenem. The resistance of *Serratia marcescens* to cefuroxime sodium resulted in a delayed reduction in the patient's temperature. Following a switch to meropenem for a 3-day course of anti-infective therapy, a gradual decline in the patient's temperature was observed. Nevertheless, as the primary infection site was not entirely eradicated, the infection remained incompletely controlled. Following the normalization of the patient's temperature, surgical intervention was promptly conducted. Despite the inflammatory markers not exhibiting a decrease at that juncture, the persistent nature of the infection, attributed to lung cancer, posed challenges in achieving control. With the lung cancer advancing, delaying surgery risked missing the optimal timing; consequently, surgery was performed on the 14th day post-admission. Following the surgery, the patient experienced amelioration in the cough and hemoptysis symptoms, alongside a gradual normalization of infection markers. Subsequently, the patient was discharged at 2 weeks post-surgery. Research has indicated that early screening and surgical intervention for lung cancer complicated by LA can yield favorable outcomes (7,14). Given the favorable prognosis observed in the patient, the surgical timing in this instance appears to have been appropriately chosen. Following discharge, the patient received regular follow-up care and maintained a normal lifestyle, undergoing periodic reevaluations. Subsequent reexaminations revealed no discernible abnormalities, the absence of tumor recurrence and the absence of any postoperative adverse events. The imaging data from the surgical intervention were not adequately retained, and so cannot provide a comprehensive visualization of the entire lung within the thoracic cavity. Consequently, there remains a deficiency in evidence-based medical data to substantiate the study conclusions. This summary encapsulates the treatment experience in this unique case and juxtaposes it with similar cases from the past, with the goal of proposing a novel clinical treatment approach for this disease subtype to enhance

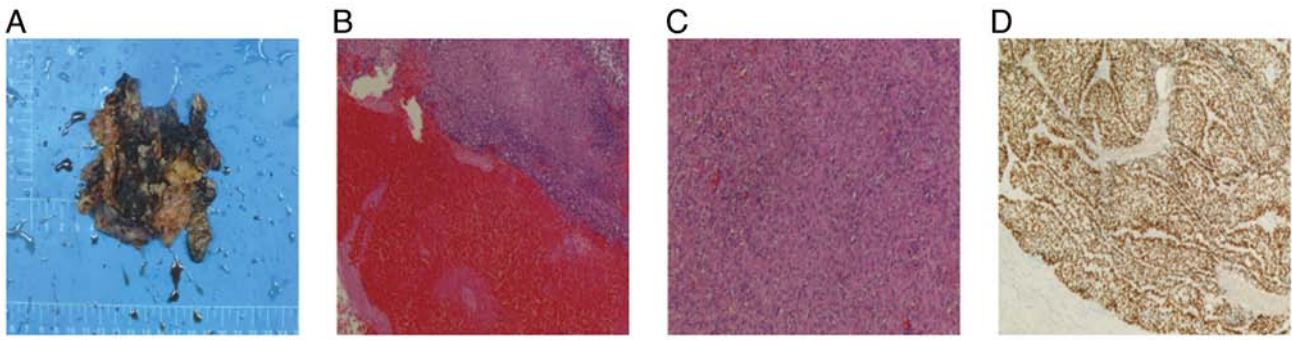


Figure 4. Pathological diagnosis. (A) Gross specimen of the tumor. (B&C) Pathological images of lymph nodes stained with H&E. (B) magnification, x40; (C) magnification, x100. No evidence of cancer cell infiltration was detected in the lymph node tissue submitted for analysis. (D) Immunohistochemical staining of cancer tissue with DAB (magnification, x100). The definitive diagnosis was squamous cell carcinoma (moderately differentiated) of the right lower lung lesion.

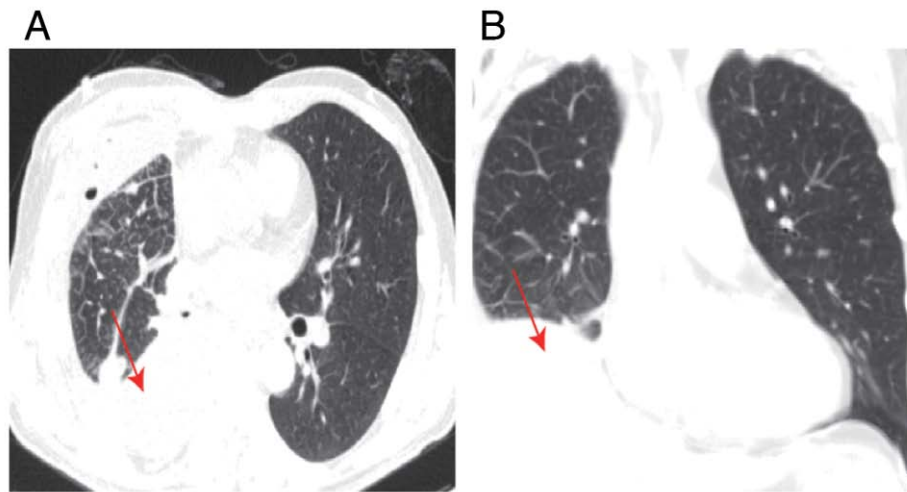


Figure 5. Results of chest CT examination at 9 months post-discharge. (A) Axial and (B) coronal CT scans of the chest. The red arrow indicates the radical resection of the right lower lung cancer. Pleural thickening was noted on the right side with a small amount of pleural effusion (partial parcel). CT, computed tomography.

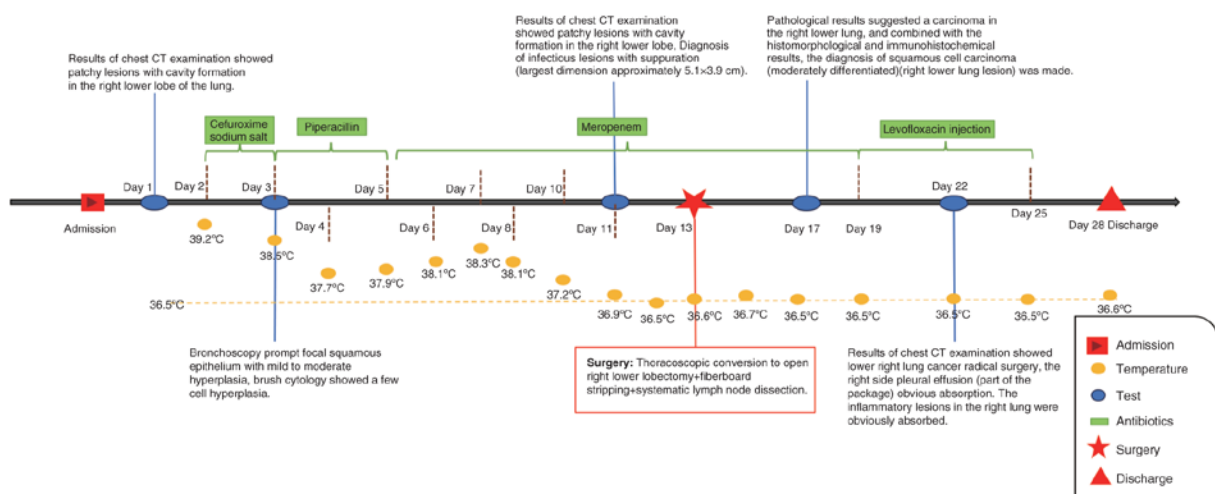


Figure 6. Timeline of diagnosis and treatment of the present patient.

patient outcomes. From a clinical perspective, further research and data are imperative to substantiate or identify improved treatment modalities.

In conclusion, we recommend that in cases of lung cancer complicated by LA, prompt surgical intervention should be considered once the body temperature normalizes and the

infection is partially controlled, as this approach may lead to improved prognostic outcomes.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

JL and YBL guided the conception and design of the study. YBL, XSL and YPT collected and analyzed clinical data and figures. YBL was responsible for writing the draft. XSL and YPT revised the manuscript. YBL conducted the second round of image acquisition and modifications. JL, YBL, XSL and YPT confirm the authenticity of all the raw data. All authors have read and approved the final version of the manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

The patient provided written informed consent for the publication of this case report and associated images.

Competing interests

The authors declare that they have no competing interests.

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