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Lung: Case Report

To Cut (Minimally Invasively) Is to Cure: Robotic Lobectomy for Pulmonary Mucormycosis

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Pulmonary mucormycosis is a rapidly progressive and highly morbid disease commonly found in immunosuppressed patients. Rapid diagnosis and treatment are essential, with thoracotomy and video-assisted thoracoscopic surgery techniques previously described for surgical resection of infected lobes. Here we present the case of a patient with acute myeloid leukemia and nonresolving *Mucor* pneumonia treated with robotic left upper lobectomy. The patient had an uneventful postoperative course and significant clinical improvement, thereby demonstrating the feasibility of the robotic approach in treating patients with invasive fungal infections of the lung.

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Pulmonary mucormycosis is a highly morbid condition found in patients with diabetes, renal insufficiency, and immunosuppression.[1] It is characterized by rapidly progressive pneumonia with resulting tissue infarction, necrosis, and rapid spread to contiguous structures.[2] Early diagnosis and aggressive treatment with antifungal agents and surgical debridement are essential to prevent rapid morbidity and mortality.[3] Various surgical approaches, including thoracotomy and video-assisted thoracoscopic surgery (VATS), have previously been described.[4] However, there is a dearth of published literature evaluating the use of robotic surgery to treat pulmonary mucormycosis. We present the case of a patient with nonresolving *Mucor* pneumonia in the setting of acute myeloid leukemia who was treated with robotic left upper lobectomy.

A 50-year-old man with acute myeloid leukemia who was undergoing induction chemotherapy was found to have a left upper lobe (LUL) lesion after new-onset pleuritic chest pain developed. Imaging demonstrated a cavitary lesion in the LUL with adjacent consolidation (Figure 1). Thoracic surgery was consulted for presumed left lung mycetoma, but surgery was initially deferred as a result of abnormal pulmonary function test results (forced vital capacity, 70% of predicted; forced expiratory volume in 1 second, 69% of predicted; diffusing capacity of lung for carbon monoxide, 13% of predicted) and poor nutritional status (body mass index, 18 kg/m^2; albumin, 2 g/dL). He was treated with amphotericin B, without improvement. Subsequent bronchoscopy with biopsies revealed *Mucor* infection (Figure 2). Given his clinical stability, we repeated pulmonary and nutritional testing before surgery. Repeat pulmonary function tests showed an improvement in lung function (forced vital capacity, 73% of predicted; forced expiratory volume in 1 second, 80% of predicted; diffusing capacity of lung for carbon monoxide, 35% of predicted). A ventilation-perfusion scan showed LUL (including lingula) perfusion to be 20% (left lower lobe, 13%; right lung, 67%). His nutritional status also improved (repeat albumin, 3.5 g/dL; prealbumin, 23.7 mg/dL; repeat body mass index, 20 kg/m^2). Therefore, the decision was made to proceed with robotic left upper lobectomy for source control.

In the operating room, he was intubated with a double-lumen endotracheal tube and placed in the right lateral decubitus position. The left side of the chest was accessed with two 8-mm robotic ports (camera and accessory arms), two 12-mm robotic ports (right and left robotic working arms), and a 12-mm assistant port. As shown in the Video, dense adhesions between the LUL and the chest wall at the apex and mediastinum were

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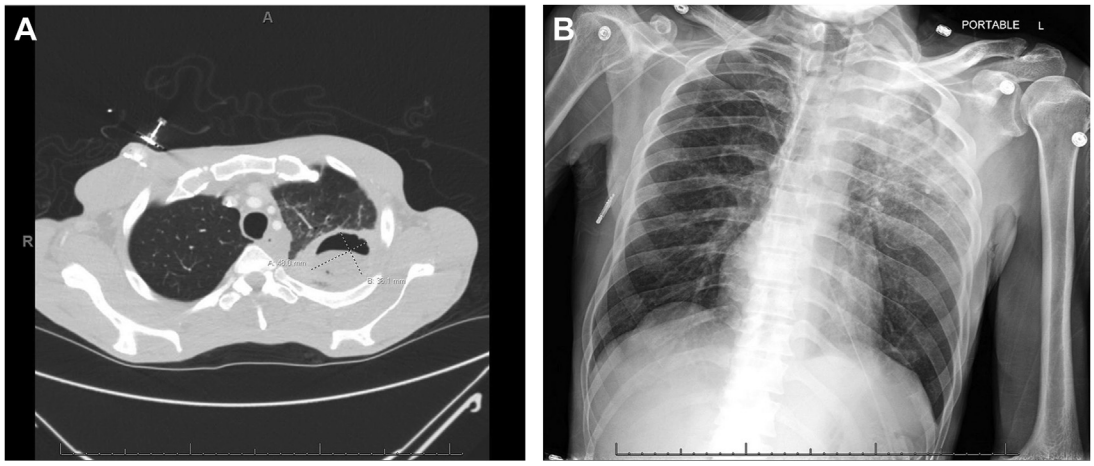

FIGURE 1 (A) Preoperative chest computed tomography showing a soft tissue density–filled cavitary lesion in the left upper lobe with surrounding consolidation (B) Preoperative chest roentgenogram showing a left upper lobe air crescent sign with a fungal ball and surrounding consolidative opacities. (A, anterior; L, left; R, right.)

discovered on entry and divided. During dissection, the cavity of the LUL was entered, and a purulent, greenish intracavitary mass was removed and sent for culture and pathologic examination (Figure 3). Interestingly, the hilum appeared free of adhesions and was dissected fairly easily as a result of significant tissue edema, which allowed tissue planes to separate. This was followed by division of the inferior pulmonary ligament, identification of both left pulmonary veins, and division of the superior pulmonary vein with a white load robotic stapler. The upper lobe bronchus was easily isolated and divided with a green load robotic stapler. Anterior and posterior branch arteries to the LUL were next identified and divided with a white load robotic stapler. Significant scarring was encountered near a large lingular artery, which complicated the dissection and required division of the fissure before arterial division. The remaining fissure was divided, and the lobe was eventually removed in a Gore-Tex (W.L. Gore & Associates) bag. Given the infectious nature of the case, an intercostal muscle flap was harvested using a robotic spatula and was used to buttress the bronchial stump. Intraoperative images of the specimen are shown in the Supplemental Figure. The total operative time was 4 hours and 54 minutes, with 215 minutes of console time. Estimated blood loss was 800

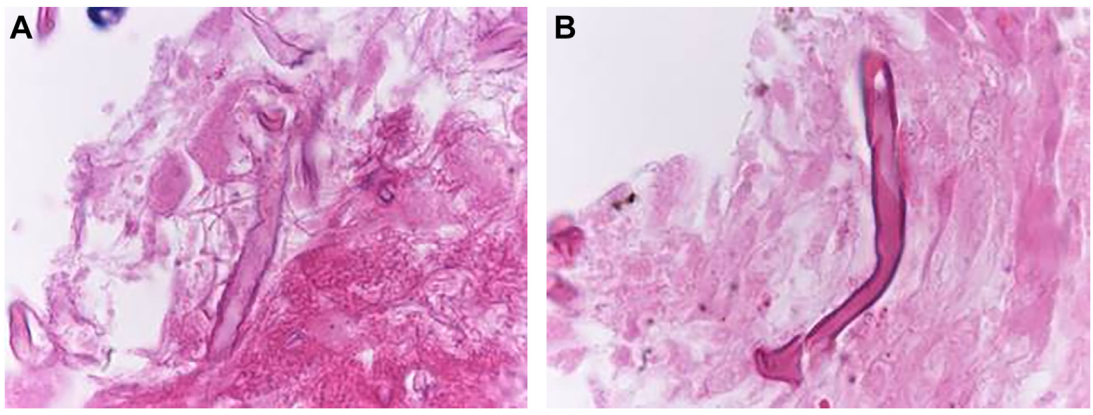

FIGURE 2 (A, B). Histopathologic images from tissue biopsy showing broad, pauciseptate, ribbon-like hyphae with occasional 90° branching consistent with a Mucorales mold infection.

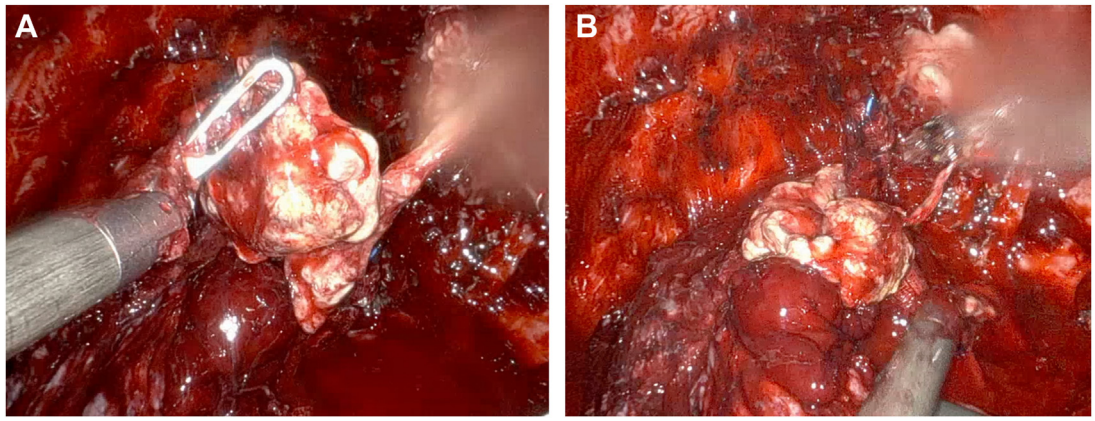

FIGURE 3 (A, B). Intraoperative images showing an intracavitary mass encountered in the left upper lobe parenchyma during dissection.

mL. Two units of packed red blood cells were transfused intraoperatively because of a low starting hematocrit of 22%.

The patient recovered well postoperatively. Repeat imaging demonstrated resolution of the LUL cavitary lesion with a small residual left hydropneumothorax. The thoracostomy tube was removed on postoperative day 7 after a 24-hour clamp trial. Besides a prolonged air leak, the patient had no perioperative complications. Because of a lack of insurance approval for home infusions, he remained inpatient to receive daily amphotericin B infusions for 6 weeks postoperatively. He was discharged on postoperative day 43. He recovered well and was recently seen in clinic with repeat computed tomography of the chest negative for recurrent or residual infection.

The final pathologic examination of the intracavitary lesion revealed necrotic debris harboring fungal organisms consistent with mucormycosis. LUL pathologic examination showed organizing pneumonia, interstitial chronic inflammation with eosinophils, granulomatous lymphadenitis, and abscesses. Immunohistochemical staining excluded the presence of a hematologic malignant disease in the specimen.

COMMENT

Pulmonary mucormycosis is an aggressive opportunistic fungal infection found in immunosuppressed patients. Given mortality rates of up to 80% with disseminated disease, early diagnosis and rapid treatment are essential.[5] Our patient received a diagnosis of suspected fungal pneumonia while he was undergoing induction chemotherapy for acute myeloid leukemia with pancytopenia. After multiple negative bronchoalveolar lavage culture results, bronchoscopy with tissue biopsy was pursued and demonstrated Mucorales. This case highlights the difficulty in isolating *Mucor* for definitive diagnosis when fungal culture results are often negative, thus necessitating invasive testing. Our patient met indications for surgery because of the presence of localized infection, ineffective past medical treatment, and a high risk of spread to adjacent lung tissue in the setting of immunosuppression and hematologic malignant disease. His poor pulmonary and nutritional reserve increased his risk of perioperative complications. Given that he was stable on room air, we deferred operative intervention until clear pathologic diagnosis of *Mucor* infection was obtained, along with evidence of improvement in pulmonary and nutritional reserve on repeat testing. There are significant challenges associated with surgical decision making in these debilitated patients, in whom postoperative morbidity and mortality are significant and correct timing of surgical intervention is crucial.

Another notable clinical feature was the slowly progressive nature of pulmonary disease with a confined intracavitary mass instead of the rapid, diffuse, necrotizing infection characteristic of mucormycosis. This finding may be related to a difference in underlying Mucorales species, where infection with some species (non-*Rhizopus,* non-*Lichtheimia* spp) is associated with a more indolent course.[6] Certain groups of patients, including patients with diabetes and immunocompetence,

have been shown to experience chronic disease with confined, discrete endobronchial lesions, thus making surgery the mainstay of treatment for source control.[7]

Thoracotomy and VATS approaches have previously been described, whereas our report discusses the robotic approach to treat pulmonary mucormycosis. Previous studies comparing the robotic approach to thoracotomy and VATS in lung cancer have revealed a shorter surgical duration compared with thoracotomy and shorter length of stay compared with thoracotomy and VATS approaches.[8] The robotic approach also affords greater surgical precision, range of motion, and ergonomics compared with VATS, features that were advantageous in this technically difficult case.

At a time of widespread adoption of robotic surgery in the thoracic surgery community, the successful completion of this robotic upper lobectomy should help inform thoracic surgeons regarding the applicability and technical challenges of a robotic approach for pulmonary mucormycosis.

The Supplemental Material can be viewed in the online version of this article [https://doi.org/10.1016/j.atssr.2024.06.005] on http://www.annalsthoracicsurgery.org.

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