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# Surgical management of a COVID-19-associated necrotic pneumonia

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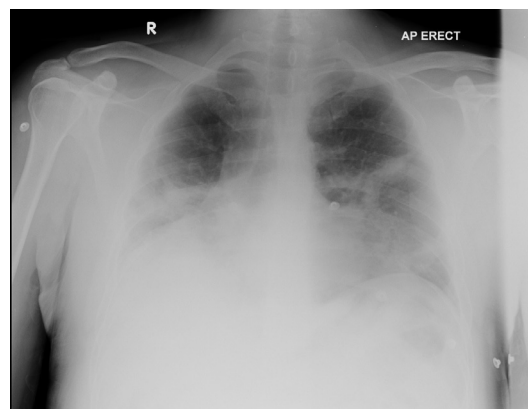
## SUMMARY

At the outset of the pandemic, SARS-CoV-2 was thought to present simply as persistent cough and fever. However, with time, the medical community noted a myriad of associated symptoms well-described in the literature. Medical complications were particularly common in elderly populations and many early publications described pneumonia, organ failure, acute respiratory distress syndrome, hypercoagulability/microthrombosis and superimposed bacterial/viral infections. There is, however, a lack of literature describing surgical complications of COVID-19 and as such little knowledge regarding safe surgical interventions. This case describes the presentation/management of a patient who developed COVID-19-associated necrotising pneumonia. Video-assisted thoracoscopy lobectomy was performed following CT demonstration of necrotising pneumonia. Pathological evaluation of the surgical resection specimen demonstrated the microarchitecture of a severely diseased COVID-19 lung-fibrosis. This case demonstrates the safe management of a necrotic lung using a minimal access approach in the context of COVID-19 infection.

## BACKGROUND

Necrotising pneumonia is a relatively rare complication of community-acquired pneumonia. Necrosis is defined as cellular/tissue death typically in the context of poor parenchymal oxygenation. Pathogenesis may relate to either (1) organism-associated toxin production or (2) parenchymal ischaemia secondary to vasculitis/microthrombosis. Liquefaction and cavitation represent the primary pathological and radiological features. Subsequent severe sepsis and respiratory failure are associated with high mortality. Unfortunately, medical management in the form of intravenous antibiotics is limited secondary to reduced lung parenchymal vascularity. CT-guided percutaneous drainage is important in management of cavitating disease. However, surgery forms the primary treatment modality in the setting of failed medical management. In particular, surgery is indicated in the context of empyema, massive haemoptysis, gangrene and non-resolving abscess.

Surgical management of necrotising pneumonia takes many forms including lobectomy, pneumonectomy, sublobar and wedge resection. Mortality is high (up to 30%) and so surgery is undertaken in tertiary referral centres under the care of thoracic surgeons (with reported mortality as low as 8%).<sup>1</sup> Few reports describe the outcomes of surgical resections of necrotic lungs in established COVID-19-positive patients.<sup>2-4</sup>



**Figure 1** CXR at index admission. The patient was diagnosed with COVID-19. Chest radiograph demonstrated right basal atelectasis. CXR, chest X-ray.

The pathological association between COVID-19 and necrotic lung is yet to be established. However, there are striking similarities in the underlying pathology of the two. As stated above, microthrombi-induced and vasculitis-induced parenchymal hypoxia is central in the aetiology of lung necrosis. Autopsy reports of COVID-19 victims, demonstrate significant capillary congestion and associated microthrombi.<sup>5 6</sup> Both small and large pulmonary vessel thrombosis have been widely reported. These similarities are interesting.

Throughout the pandemic, surgeries were cancelled in an endeavour to both redirect services and avoid increased morbidity/mortality associated with COVID-19 infection, in patients undergoing elective and emergency surgery. COVID-19-positive patients undergoing cardiothoracic surgery were thought to have poor outcomes. COVID-19-induced necrotic lung represents a particular case. The authors demonstrate the safe and efficacious management of a necrotic lung secondary to COVID-19.

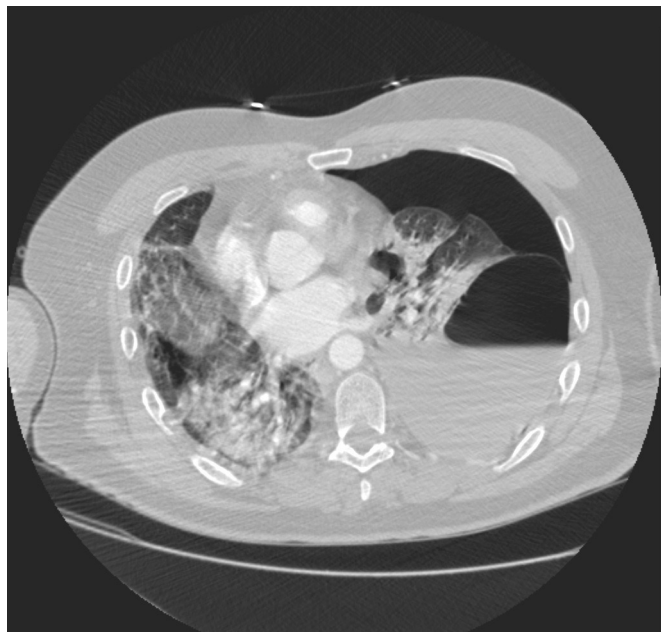
## CASE PRESENTATION

A 47-year-old man presented to hospital with symptoms typical of COVID-19 infection. Symptoms were ongoing for 2 days (fever, sweats, cough and shortness of breath). Nasopharyngeal swab confirmed the diagnosis of COVID-19. Chest X-ray (CXR) demonstrated right basal atelectasis (figure 1). Inpatient duration was 3 weeks during which time 2 days of ventilatory support were required in the form of continuous positive airway pressure. Cardiovascular inotropic support was not required. The patient was treated with



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**Figure 2** CT pulmonary angiogram demonstrated left hydropneumothorax. There were multiple air fluid levels distributed throughout the left lower pleural cavity. Delineation between the left lower lobe and fluid collection was not clear. The differential remained pleural collection, parenchymal collection, necrosis and abscess.

dexamethasone as part of the recovery trial (study ID 50189673) and discharged after a 3-week period.

Two weeks following his original admission, he represented with chest pain and shortness of breath at which point his COVID-19 tests were negative. CT pulmonary angiogram (CTPA) showed a large left hydropneumothorax. Air fluid levels were seen in the collection which comprised the entirety of the left lower pleural cavity. The imaging did not clearly delineate between the left lower lobe/fluid collection and so the differential between parenchymal abscess, necrotic lung and empyema was unclear. The right lung demonstrated patchy basal consolidation and a small air fluid collection consistent with COVID-19 infection (figure 2). Empirical antimicrobial therapy in the form of clarithromycin and piperacillin/tazobactam was commenced at the referring hospital. Antibiotics were escalated to meropenem on transfer to the regional thoracic centre. An intercostal drain was inserted with an anterior approach, using Seldinger principles. Pleural fluid sampling demonstrated a pH of 7.1 indicative of infection. Microbiology cultures were reported negative but the patient was on broad spectrum antibiotics prior to sampling. However, this intervention failed to drain the pleural cavity (online supplemental figure 1).

Imaging failed to differentiate between empyema, parenchymal abscess and necrotic lung. As such, lytic therapy was not considered. The patient underwent a left uniportal video-assisted thoracoscopy 6 weeks after his initial presentation with the intent of performing a left pleural washout and decortication. However, on visualisation of the lung it became apparent that pathology was primarily intraparenchymal rather than pleural. The lower lobe was dark in colour, friable and clearly necrotic (figure 3). The surgical team proceeded to left lower lobectomy.

## OUTCOME AND FOLLOW-UP

The patient returned to the ward where antibiotics were continued. An immediate fall in white cell count and C reactive

protein was noted with continued decline toward normal (online supplemental figures 2 and 3). Sinus tachycardia persisted for 2 weeks but was resolved by the time of discharge. No further surgical intervention was required following return to baseline physical function. Antibiotics were discontinued at the point of discharge. The patient was mobile and independent in activities of daily living. There was no subsequent readmission. CXR at the time of discharge demonstrated clear pleural spaces with loss of volume in the left hemithorax consistent with his post lobectomy status (online supplemental figure 4).

Macroscopic inspection of the lung following slicing demonstrated a pale firm lung, large haematoma in the superior segment, organising pneumonia and large airway oedema. Microscopic evaluation demonstrated bronchial oedema, large organising encapsulated haematoma, severely distorting lung parenchymal and subpleural fibrosis indicating some degree of chronicity to the pathological process.

## DISCUSSION

Lung necrosis is a known rare complication of community-acquired pneumonia. Only few reports of lung necrosis secondary to COVID-19 infection exist. Consequently, there is a lack of evidence regarding safe management strategies. The two pathologies are strongly associated with poor prognosis. This case describes the successful surgical management of COVID-19-induced lung necrosis.

The aetiology of post COVID-19 lung necrosis is undetermined. The following three pathologies are feasible: (1) direct viral-induced lung necrosis, (2) superimposed bacterial infection with consequent lung necrosis and (3) thrombosis/infarction of lung parenchyma.<sup>7</sup> Renaud-Picard *et al*<sup>8</sup> reported a case similar to the current report and concluded that COVID-19-associated lung abscess was the most likely aetiology. A 59-year-old woman developed COVID-19-associated respiratory failure mandating intensive care admission/respiratory support. She re-presented, following discharge, with a lung abscess. Her treatment comprised of 3 weeks of intravenous antibiotics but no surgical intervention. The authors considered microthrombi secondary to COVID-19-induced hypercoagulability as a possible cause.



**Figure 3** Macroscopic specimen of part of left lower lobe. The parenchyma is diffusely firm with patches of fibrotic and necrotising areas.

However, the patients' allergy to contrast precluded CTPA and their primary hypothesis remained as COVID-19 pneumonia complicated with abscess formation.

Many of the pathological features noted in our patient have been widely reported in postmortem lung biopsies of COVID-19 cases including airway oedema, pulmonary haemorrhage, acute fibrinous and organising pneumonia.<sup>8</sup> This further validates our hypothesis that COVID-19 is the likely aetiology. It is possible, however, that superimposed bacterial infection initiated the necrotic process. *Staphylococcus aureus* is the most commonly associated postviral infectious agent leading to necrosis and it is possible that bacterial infection was the index infection leading to necrosis.<sup>9</sup>

Goursaud *et al*<sup>10</sup> described a case of COVID-19 lung necrosis and tentatively associated the disease with a prothrombotic state. COVID-19 is known to induce a hypercoagulable state with capillary stasis and coagulation cascade activation, leading to microthrombi formation. Most commonly, COVID-19 hypercoagulability presents as coronary, cerebrovascular and pulmonary artery occlusion. It may occludes smaller vessels, including bronchial arteries with subsequent parenchymal infarction, leading to necrosis.<sup>11</sup>

Interestingly, the patient in Goursaud's study and the patient in the Renaud-Picard's case report were diagnosed with COVID-19 pulmonary complications at representation. This highlights a pressing need for a structured follow-up process catering for earlier diagnosis of pathology that is associated with

high mortality. Furthermore, there is also a need for a pathology and microbiology repository of postmortem findings to allow us better understand this disease.<sup>12</sup>

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**Disclaimer** Case reports provide a valuable learning resource for the scientific community and can indicate areas of interest for future research. They should not be used in isolation to guide treatment choices or public health policy.

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## Learning points

- There is a likely association between COVID-19 infection and development of necrotising pneumonia. Autopsy reports of COVID-19 victims demonstrate significant capillary congestion and associated microthrombi.
- The aetiology of post COVID-19 lung necrosis is undetermined. The following three pathologies are feasible: (1) direct viral-induced lung necrosis, (2) superimposed bacterial infection with consequent lung necrosis and (3) thrombosis/infarction of lung parenchyma.
- COVID-19 hypercoagulability presents as coronary, cerebrovascular and pulmonary artery occlusion. It may occludes smaller vessels including bronchial arteries with subsequent parenchymal infarction leading to necrosis.
- COVID-19-induced necrotic lung represents a particular case. In this case, we demonstrate the safe management of a necrotic lung secondary to COVID-19.

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