



Surgical paradigm for lung injury secondary to COVID-19

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Comment on: Gamrekeli A, Ramirez-Fragoso F, Ghamarnejad O, *et al.* Surgical therapy for major lung parenchymal damage from late coronavirus disease complication: case report and literature review. *AME Case Rep* 2023;7:33.

Keywords: Coronavirus; lung surgery; minimally invasive

Received: 24 October 2023; Accepted: 09 November 2023; Published online: 12 December 2023.

doi: 10.21037/acr-23-186

View this article at: <https://dx.doi.org/10.21037/acr-23-186>

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has resulted in new aspects of lung disease and has forced the medical community to adapt treatment algorithms. The phenomenon of “long COVID”, or persistent symptoms that last for weeks to months after initial recovery, increasingly preoccupies healthcare providers (1). Among the myriad complications, lung parenchymal damage stands out as a particularly challenging issue to manage (2). The paper “Surgical therapy for major lung parenchymal damage from late coronavirus disease complication: case report and literature review” tackles this issue, laying the groundwork for a surgical approach to what is often seen as a medical problem. The authors present a series of three patients with significant lung parenchymal damage as a late complication of COVID-19. This case series is coupled with a literature review, underscoring the necessity for more focused research into this area. These case studies are especially noteworthy for the surgical interventions they describe, ranging from video-assisted thoracoscopic surgery (VATS) lobectomy to thoracotomy. The success of these operations, as reflected in the patient outcomes, paves the way for a new paradigm in managing severe lung damage secondary to COVID-19 (3).

In the tradition of innovative research, the present study elucidates certain issues while provoking a host of additional queries requiring further investigation. Specifically, the implications of opting for a surgical approach merit close scrutiny, including any disadvantages or unforeseen complications that could arise. Although the surgical

approaches led to promising results in the presented cases, it is important to explore conditions in which surgery may not represent the optimal treatment pathway (4). Moreover, the dynamic landscape of transmission rates, notably in the context of potential resurgence of COVID-19, poses challenges for surgical scheduling and resource allocation (5). Such circumstances could overstress healthcare facilities and elevate the risk to both patients and medical professionals. These are pivotal concerns that warrant detailed evaluation, particularly when viewed through the lens of thoracic surgery.

It is likely that there will be future pandemic waves and elevated community transmission rates. As such, it is critical to have clear indications for surgery on patients with COVID-19 and lung injury, perioperative adjuncts to surgical treatment, and how to account for spikes in disease in the surrounding population.

Preoperative management

The preoperative management strategy for severe lung parenchymal damage secondary to COVID-19 should include a multidisciplinary approach, with integration of medical, surgical and critical care disciplines to achieve the best possible outcomes. Initially, it is important to establish appropriate antibiotic stewardship to administer appropriate treatments for COVID-19 and to diagnose any potential superimposed bacterial infections. Tailored antibiotic regimens, based on the results of culture sensitivities and local antibiogram, can mitigate the risks of secondary

infections and adverse drug reactions. Administration of Paxlovid, an oral antiviral treatment, should be considered as part of the preoperative management provided that the patient's disease course is within the therapeutic window for Paxlovid. Potential interactions and contraindications should be considered, particularly when used with multiple other antibiotic agents (6). A high level of vigilance and advanced monitoring in an intensive care unit (ICU) setting are warranted to observe closely the patient's respiratory status, hemodynamic stability and other clinical parameters. Attentive monitoring in the early phases of disease may help to reduce significant complications like parenchymal damage and allow for treatment to be performed at an early stage of disease should parenchymal damage occur (7). Prior to surgical intervention, percutaneous strategies like small bore catheter or tube thoracostomy can be employed to manage pleural effusions on pneumothorax. These complications, which are commonly seen in patients who develop parenchymal damage, may help to stabilize the patient and decrease overall surgical risk (8). Employing specific ventilation strategies can also help to prevent ventilator-induced lung injury. Utilizing lung-protective ventilation with lower tidal volumes and positive end expiratory pressure tailored to the patient's lung compliance can be beneficial. Most importantly, treatment of these patients can be very complex. The formation of multidisciplinary teams for nutritional support, physiotherapy, and psychological support may contribute to optimizing the patient's preoperative status and make a successful outcome more likely (9). These strategies should be used in a nuanced fashion, with evolving evidence and patient response as guides during the treatment course.

Discussion

Indications for surgery

Despite the promise of surgical techniques, determining when to intervene requires careful evaluation of clinical factors, extent of disease and the potential for alternative treatments. A clear delineation should be made between patients in the acute phase of COVID-19 infection and those in the post-infectious period suffering from complications. It is important to have a comprehensive understanding of the patient's COVID-19 status at the time of surgery. Is the patient still positive by polymerase chain reaction (PCR) assay? Was there a concurrent bacterial infection complicating the clinical picture? These factors

may influence perioperative management, but the decision for surgery should primarily hinge on the aforementioned clinical indications (10). Also, there should be broad multidisciplinary discussions prior to surgery. There are specific indications for surgical treatment of patients with lung injury secondary to COVID-19:

- ❖ Hemoptysis: uncontrolled bleeding in the airways poses a direct risk of airway compromise, hemodynamic instability and eventual respiratory failure. In the context of lung damage secondary to COVID-19, hemoptysis can occur with significant parenchymal necrosis. If endovascular techniques cannot control the source(s) of hemorrhage, then surgery may be necessary to control bleeding (11).
- ❖ Hemothorax: if blood has accumulated in the chest and cannot be evacuated percutaneously, surgical evacuation and control of the bleeding source are indicated. Evacuation of the hemothorax should be performed as soon as possible after discovery to facilitate complete evacuation (12).
- ❖ Air leak: significant parenchymal damage can lead to a parenchymal air leak. Manifestations of such an air leak can be prolonged need of a chest tube, development of subcutaneous emphysema or respiratory insufficiency from poor ventilation. In post-COVID patients, lung injury can lead to these complications. Surgery is indicated when there is a failure of conservative management and endobronchial valve exclusion is not possible (13).

Consideration of population transmission rates and prevalence of disease

The feasibility of thoracic surgery during a pandemic will be influenced by population transmission rates and the prevalence of the disease in the community. This scenario emphasizes the need for health facilities to be adaptive in response to these fluctuations. As COVID-19 transmission rates rise, healthcare systems face challenges related to increased patient load, potentially reduced available personnel (due to staff infections or quarantine) and increased utilization of resources for COVID-19 care. Most centers had to reduce or cancel elective cases during the height of the initial surge of illness in 2020. Future waves may affect surgical scheduling, requiring prioritization based on the urgency of the procedure and the risk of exposure to healthcare providers (14). The risk of intra-hospital transmission can be exacerbated during times of

high disease prevalence. Many patients with parenchymal damage secondary to COVID-19 infection will be hospitalized upon diagnosis and require emergent/urgent surgery. But some patients with parenchymal damage may need to be stabilized with nonsurgical treatments during a surge of disease until the community prevalence decreases. Proactive screening and isolation protocols should be strengthened during these times.

A surge in cases can lead to a significant diversion of resources, including ICU beds, ventilators, and medical personnel, to manage the acute phase of the disease. This can lead to potential delays in post-operative care for thoracic surgery patients, who might require intensive monitoring and support. Hospitals need to develop dynamic resource allocation strategies that can be adjusted based on the current prevalence and transmission rates (15). Patients should be apprised of the risks associated with undergoing surgery during times of high disease prevalence. This includes potential delays in receiving care, increased risk of exposure, and the unpredictability associated with resource allocation during surges. A shared decision-making model can ensure that patients are making informed choices about their care (16). In regions with multiple healthcare facilities, collaboration can be the key to managing high patient loads and ensuring that those requiring surgical interventions receive timely care. Hospitals can develop inter-facility transfer protocols to manage patient load and ensure optimal utilization of resources (17).

Surgical technique

Both robotic and VATS offer the advantage of smaller incisions, leading to decreased post-operative pain, shorter hospital stays, and quicker recovery. For patients with lung parenchymal damage secondary to COVID-19, a minimally invasive approach can be particularly beneficial to reduce the systemic stress response and preserve respiratory function. Selection criteria for these procedures should consider the extent of disease, patient's overall health status and surgeon's expertise (18).

In bilateral lung damage from COVID-19, the primary consideration should be patient stability. If both lungs are compromised but the patient is stable, addressing one side first and assessing patient recovery before proceeding with the second side may be prudent. In severely compromised patients where delay might result in further deterioration, bilateral surgery in a single setting might be necessary (19).

While the authors allude to the utilization of

minimally invasive techniques, there is a noted mention of thoracotomies in some cases. It is essential to clarify what is meant by "minimally invasive". In the realm of thoracic surgery, while VATS and robotic procedures are indeed minimally invasive, thoracotomies are not. Clearer delineation between the techniques used and the reasoning behind them would strengthen the narrative and eliminate any potential confusion. Thoracotomy, though sometimes essential based on the case's intricacies, is a more invasive procedure with prolonged recovery times (20). It is important to clarify the specific circumstances necessitating thoracotomies, particularly when minimally invasive techniques might be presented as the primary approach.

Bacterial infections can augment inflammatory responses and produce purulent secretions, complicating the dissection and increasing technical difficulty of the surgery. The degree and magnitude of adhesions may increase the risk of conversion to an open procedure. But most procedures can usually be begun minimally invasively with an overall low conversion rate (21). When there is extensive parenchymal damage, a procedure such as a modified thoracoplasty may be required. Once the patient is stabilized and the acute episode has resolved, delayed reconstruction with a vascularized flap may be appropriate.

Thorough discussions should be had with other services such as the intensive care, pulmonology and infectious disease teams prior to surgery. Anticipating postoperative patient requirements ahead of time will help to treat potential complications. Preoperative planning should address any possible intraoperative problems, such as difficult ventilation, poor oxygenation and management of fluid status. Appropriate monitoring devices should be used during surgical intervention.

Post-operative management

Postoperative management should be tailored to the patient's clinical condition. Chest tubes may be required for quite some time, but generally can be removed once air leaks have resolved and fluid output is minimal. Given the nature of damage to the lung parenchyma in these patients, there is an increased risk of postoperative bleeding and respiratory failure. In cases of significant bleeding, re-exploration may be necessary. Respiratory compromise might require prolonged mechanical ventilation or reintubation (22). In cases where conventional ventilatory support is insufficient, extracorporeal membrane oxygenation (ECMO) can be a life-saving adjunct. It should be considered especially in

patients who are deteriorating despite maximal conventional support (23). The survival rate after surgery will vary based on the extent of lung damage, patient's overall health and other co-morbid conditions. Long-term follow-up studies are required to provide a clearer picture (24). Some patients might have prolonged respiratory compromise requiring extended ventilatory support. In such scenarios, tracheostomy might be beneficial for weaning from the ventilator and facilitating pulmonary toilet (25).

Conclusions

Surgical intervention for severe lung parenchymal damage secondary to COVID-19 is occasionally required in an evolving landscape of disease management. While promising, it is imperative to approach with caution. Caregivers should evaluate patients carefully and thoroughly in a multidisciplinary fashion prior to entertaining surgery. It is important to consider all possible surgical procedures, ranging from evacuation of a pleural effusion to thoracoplasty. Overall, these surgeries can be performed safely but they will generally be more technically challenging than elective resections for cancer. The long-term implications of such interventions, both in terms of patient survival and quality of life, are not yet fully understood. As the medical community continues to grapple with the challenges of COVID-19, innovative strategies such as these surgeries will be instrumental in shaping future treatment paradigms.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *AME Case Reports*. The article did not undergo external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <https://acr.amegroups.com/article/view/10.21037/acr-23-186/coif>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are

appropriately investigated and resolved.

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doi: 10.21037/acr-23-186

Cite this article as: Behinaein P, Hutchings H, Okereke IC. Surgical paradigm for lung injury secondary to COVID-19. *AME Case Rep* 2024;8:1.