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# Organization of thoracic surgical services during the COVID pandemic



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## ABSTRACT

**Introduction:** COVID-19 presented an unprecedented challenge for healthcare workers and systems around the world. Healthcare systems have adapted differently in terms of pandemic planning of regular services, adopting infection control measures and prioritising essential hospital services in the context of a burgeoning COVID-19 patient load and inevitable surge.

**Methods:** We performed a review on current evidence and share our practices at a teaching hospital in Singapore.

**Results:** We outline principles and make recommendations for continuity of delivering essential thoracic surgical services during this current outbreak.

**Conclusions:** The maintenance and provision of thoracic surgery services in this context requires good preplanning and vigilance to infection control measures across all levels.

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## Introduction

The World Health Organization (WHO) declared the COVID-19 outbreak a pandemic on 11 March 2020. Since then the number of COVID-19 patients has increased drastically across the world. Compared to Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS), COVID-19 is much more transmissible although its case fatality rate is reportedly lower.<sup>1</sup> However, we have seen the effects of large COVID-19 outbreaks straining healthcare systems such that the mortality escalates exponentially. In spite of all this, healthcare systems still need to continue basic provision of essential services. It is inevitable that during a time of pandemic, services may encounter patients who retrospectively get diagnosed with the disease whilst undergoing a separate planned procedure.<sup>2</sup> Institutions must calibrate their response in accordance with the country's health ministry.<sup>3</sup> In Singapore, a Disease Outbreak Response System Condition (DORSCON) framework is adopted. We discuss the various

facets of continued provision of thoracic surgical services during and after a pandemic such as resource distribution, infection control measures, prioritization of surgery, inpatient, perioperative and outpatient management, research activities and ethical considerations. We elaborate on specific measures that are available in literature and practiced in our institution that can be implemented during this crisis. We also include suggestions on resumption of services post lockdown. This article focuses on the provision of thoracic surgical services for patients with lung pathologies.

## Materials and methods

We systematically searched PubMed from inception to 27 June 2020 for articles relating to thoracic surgery during pandemics. We used the keywords and Medical Subject Headings (MeSH) terms: COVID-19, COVID, SARS-CoV-2, nCoV, Severe Acute Respiratory Distress Syndromes or SARS, H1N1, Middle

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East Respiratory Syndrome or MERS, thoracic surgery, surgery, mediastinal cancer, lung cancer, pandemic in varying combinations. We included studies in English and excluded animal studies. The references of the studies were further hand searched manually. We also web searched guidelines published by recognized medical and surgical bodies in addition to our national guidelines for recommendations relevant to thoracic surgery (Supplementary Table 1). The final references compiled related to the topics covered in developing a comprehensive action plan for thoracic surgical services in a pandemic.

## Planning of services

### Resource distribution and workflows

Pre-emptive planning of surgical resources prior to a pandemic or in the early stages of a pandemic is crucial.<sup>4</sup> Drawer plans for continuity of services must be formulated early and implemented before the pandemic hits.<sup>5</sup> Team segregation of manpower should be considered at all levels from senior leadership and consultants down to the junior manpower accounting for the clinical and administrative capabilities of each team member.<sup>4,6,7</sup> Decreasing interactions between healthcare workers (HCWs) reduces the risk of transmission within the division.<sup>8</sup> Clear lines of communication must be maintained at all times to ensure that ward rounds, operating theatre and outpatient clinic schedules do not conflict.<sup>7</sup> Geographical segregation should be outlined such that at any one time only one team is present at each location. An example roster which balances the work rest cycle is demonstrated in Table 1. Such segregation helps with contact tracing if exposure occurs to a staff member and prevents the disruption of services should any member of staff fall ill.<sup>9</sup> Staff segregation is a dynamic continual process that has to be constantly tweaked according to current manpower status.<sup>3,10</sup>

In the event of a surge, stricter measures of segregation should be considered and staff may be required to rotate duties and alternate work weeks. Non clinical support and administrative staff should be encouraged to telecommute and adhere to social distancing.<sup>5,7,9,11,12</sup> This will require information technology infrastructural support which may not be available in some systems. Tumour boards and department meetings should be conducted over video conferencing platforms to minimize HCWs transmission.<sup>3,7,9,11–15</sup>

Pandemics like COVID-19 are unpredictable in its duration and may be prolonged. HCWs should be judicious in the usage and disposal of personal protective equipment (PPE) and take responsibility in not depleting resources unnecessarily.<sup>9</sup>

Institutions must ensure sufficient stockpile of material resources such as ventilators, masks and gloves.<sup>16</sup> In a protracted pandemic, HCW fatigue and burnout will surface and hospitals should consider provisions for psychological and welfare support for its staff.<sup>6,7,10,13,16–18</sup> Institutions should be aware that as the last line of defence, reversal of this segregated posture would only take place after the pandemic is well and truly over.

### Outpatient clinics

During an outbreak, patient and visitor attendance in the outpatient setting must be restricted.<sup>4,7,19</sup> Patients and accompanying relatives attending to the hospital should be screened for recent travel history, exposure history, temperature and upper respiratory tract illness (URTI) symptoms at triage.<sup>9,13,20</sup> As thoracic surgery patients often have respiratory symptoms, extra vigilance and precautions should be given to these patients.<sup>21</sup>

In addition, pro-active screening of scheduled outpatient appointments must be considered by physicians. Patients scheduled for follow up visits may be tele consulted and postponed if stable.<sup>3,4,9,13,14,22</sup> Patients on routine surveillance follow up post lung cancer resection can be mailed their radiological reports and the results can be explained over the phone.<sup>4,12,13,23</sup> Given the highly sensitive nature of breaking new diagnosis of cancer or counselling for surgery, we do not advise doing these remotely.<sup>3,24</sup> First visit consults and pre-operative counselling should continue with the necessary infection control measures taken by HCWs. Where possible, elective admissions from the clinics should be minimized and same day admissions encouraged to minimize patients' stay in hospital as well as decrease utilization of hospital resources. Beyond this pandemic, hospitals should explore permanent transition of part of its outpatient load into telemedicine.

### Patient transfers

As a tertiary referral centre, we entertain on a daily basis requests for transfer for thoracic surgical support from other peripheral hospitals. Our national policy recommends patients who have URTI symptoms or infective cases (i.e. empyema, lung abscesses) have two COVID-19 swab negative samples 24 h apart before transferring between institutions.<sup>17</sup> Patient transfers should be tracked and senior hospital authorities involved in the approval process of patient transfers so as to maintain a macro view of the hospital's bed situation.<sup>25</sup> We advocate for a criterion for transfer considered only for patients who require clinically urgent intervention, in which the sending hospital has no expertise or capability and

**Table 1 – Example roster for team segregation.**

Location	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Inpatient wards	Team A	Team B	Team C	Team A	Team B	Team C	Team B
Operating theatre	Team B	Team C	Team A	Team B	Team C	Team A	
Outpatient clinics	Team C	Team A	Team B	Team C	Team A		

Each team should ideally consist of one specialist consultant, one resident trainee and one junior doctor or advanced practitioner nurse.

the patient cannot be remotely managed. This will minimize cross hospital contamination and transmissions. Where possible, referrals should be directed to an outpatient setting where patients can be screened on arrival to hospital as above.<sup>9</sup>

For patients who are COVID-19 positive and require inpatient transfer, we have a dedicated transfer team and protocol. The other hospital transferring team hands over the patient at a dedicated COVID-19 ambulance bay ensuring minimal physical contact of staff and equipment. The patient is then escorted by appropriately PPE attired security and medical personnel along a predetermined route to the COVID-19 wards. Front scout security personnel clear the hallways of pedestrians to avoid exposure. A dedicated lift is used solely for the transfer of COVID-19 patients. A trailing housekeeping team then follows behind the patient cleaning the environment before pedestrians are allowed to resume usage of the path.

### **Inpatient management**

An overarching principle for inpatient management is to reduce the duration of stay for patients.<sup>6</sup> Reports have shown that many patients awaiting or undergoing surgery contract COVID-19 during their inpatient stay.<sup>26</sup> We encourage same day admissions, expedited discharges to home and tele-medical outpatient follow up to reduce length of stay while delivering appropriate medical care.<sup>23</sup> Pre-operative work up should be consolidated and performed outpatient. Pre-operative pulmonary function tests should be considered only for patient who are at high risk of respiratory compromise post lung resection (e.g.: COPD, asthmatic patients).<sup>27</sup>

Thoracic surgical patients, in particular patients undergoing lung resection for cancer and immunosuppressed patients on chemotherapy, are at higher risk of contracting infections including COVID-19.<sup>2,21,26</sup> These patients are at higher risk of severe events from SARS-CoV-2 requiring intensive care unit (ICU) admission, mechanical ventilation and death.<sup>2,3</sup> A high suspicion for COVID-19 must be present when managing these patients with lung malignancies, especially if community spread is present. Patients with URTI symptoms or computed tomography findings of bilateral ground glass opacities should be screened for COVID-19 aggressively.<sup>28</sup> If found, surgery should be delayed if possible until the COVID-19 is fully resolved.<sup>9,15,29</sup>

It is inevitable that as COVID-19 pandemic progresses and lockdowns end, some patients transiting through hospitals will get the disease or bring it from the community.<sup>2,7,26</sup> We advocate applying an expanded screening criterion to screen all patients presenting to the hospital who have symptoms of URTI or findings of pneumonia, even radiologically, to reduce risk of local hospital transmission.<sup>7</sup> This practice is resource intensive and not all healthcare systems may be able to afford such extensive screening due to limitations in testing kits, PPE or manpower. In such instances, ring fencing and cohorting of thoracic surgery patients may help reduce risk of transmission amongst patients.<sup>30</sup> As most thoracic surgery patients have baseline respiratory symptoms, many will fall within this expanded screening criteria and be screened for COVID-19. As such, PPE training is mandatory for thoracic surgery

services staff as they are likely to encounter and manage COVID-19 confirmed or suspect patients.<sup>10</sup>

## **Perioperative considerations**

### **Prioritizing surgery**

Thoracic surgery entails a variety of emergency and elective cases. In times of a pandemic with limited operating theatre resources, deliberate prioritization of surgical cases should be considered.<sup>4,14,19</sup> We suggest thoracic surgical operations be stratified into emergency, urgent and elective. Emergency surgery entails life-saving operations which if not performed, would result in the imminent demise of the patient.<sup>7</sup> Urgent surgeries include those for which there are no non-surgical alternatives for management. These patients require inpatient surgery with the necessary precautions. Elective surgeries include patients with thoracic malignancies who require oncologic surgery.<sup>4,6,9</sup> Within the elective category, we further classify into high, medium and low priority.<sup>23,30–32</sup> Depending on the hospital's current resources, ICU bed and ventilator capacity and current pandemic trajectory, we suggest prioritizing them accordingly. Should the healthcare system be overwhelmed such that manpower and resources have to be diverted away from operating theatres and outpatient clinics, only emergency surgical services can be maintained and all elective and urgent surgeries postponed.<sup>3,19</sup> As the pandemic resolves, hospitals can progressively begin taking on more elective cases where resources allow. [Table 2](#) illustrates and gives examples of the above principles.

Thoracic cancers are triaged based on their radiological and histological characteristics which correlate with tumour malignant potential.<sup>30</sup> Specifically, we consider symptoms, size, percentage solid component and volume doubling time.<sup>23,31,32</sup> In addition to these considerations of tumour biology, a study during SARS showed that the psychological toll on patients awaiting lung cancer surgery especially in a pandemic are significant as well.<sup>24</sup> Patients awaiting delayed surgery due to the outbreak reported increased anxiety and depressive symptoms. Hence these patients should still be afforded their oncologic surgery if hospital resources permit, even during a pandemic.<sup>3</sup> While we know these patients are at higher risk of sustaining COVID-19 and severe complications if they transit through the hospital, we cannot predict the duration a pandemic would run and indefinitely postpone oncological surgery while the tumour proliferates.<sup>33</sup> Post-operatively, patients who require adjuvant chemotherapy or radiotherapy can be delayed up to 4 months, until the pandemic curve has crossed its peak.<sup>3,30,34</sup> In the event of a surge overwhelming surgical resources such as ICU and ventilators, non-inferior alternatives such as stereotactic body radiation may be considered if available.<sup>23,30,34</sup>

Lung transplantation must proceed with caution during a pandemic. Experience with H1N1 showed that lung transplant patients are at high risk of mortality during pandemics.<sup>35</sup> Furthermore, during a surge there may be a scarcity of resources required to support the prolonged post-operative care of a transplant patient. If transplant is performed, patients must not be actively infected with SARS-CoV-2, at least 14

**Table 2 – Prioritizing surgery during a pandemic response.**

Pandemic response according to capacity	Normal capacity				
	Extended capacity				
	Expeded capacity				
	Overwhelmed capacity				
Priority	Emergency	Urgent	Elective		
			High	Medium	Low
Examples	Threatened airway	Empyema	Lung cancer <ul style="list-style-type: none"> <li>• Solid or predominantly solid (&gt; 50%)</li> <li>• Size &gt; 2cm</li> <li>• Node positive</li> <li>• Volume doubling time &lt; 400 days</li> </ul>	Lung cancer <ul style="list-style-type: none"> <li>• Predominantly ground glass (&lt; 50% solid)</li> <li>• Size &lt; 2cm</li> <li>• Indolent histology</li> <li>• Pulmonary oligometastases</li> </ul>	Pure ground glass opacities
	Active bleeding with hemothorax or shock	Perforated cancer with sepsis	Chest wall tumors of high malignant potential	Asymptomatic mediastinal tumors	Histology proven benign tumors
	Unstable patients with surgical complications not amenable to non-surgical management	Non resolving pneumothorax	Stenting for obstructive tumors	High risk patients likely to require prolonged ICU needs	Sympathectomy for hyperhidrosis
		Pleural or pericardial effusion with tamponade risk	Surgical staging/diagnostic procedures		Pectus surgery
		Traumatic rib fractures with flail chest unable to wean off mechanical ventilation	Post induction therapy		Elective pneumothorax
		Stable patients with surgical complications not amenable to non-surgical management	Symptomatic mediastinal tumors		
Action Plan	To be done within 1 hour	To be considered during normal, extended or expended capacity: done within current admission	To be considered during normal or extended capacity: done within 1 to 3 months	Consider postponement unless normal capacity	Postponed if normal capacity exceeded

days after initial diagnosis and recipients should have 2 negative PCR-based tests at least 48 h apart prior to transplantation.<sup>36</sup> Lung transplant for COVID-19 related lung disease is possible but not advisable and warrants concomitant cardiac evaluation in view of the risk of myocarditis.<sup>37</sup> Heightened infection control measures must be adopted for patients immediately post transplantation on induction therapy as COVID-19 is also associated with lymphopenia.<sup>36</sup> Post transplant patients are at high risk of complications from COVID-19.<sup>38</sup> Ex vivo lung perfusion may be considered for time sensitive donors as a temporary hub to store donor lungs during a time of crisis.

### Infection control measures in the operating theatre

General infection control measures should be strictly adhered to, while managing thoracic surgical patients.<sup>39</sup> It has been shown in the 2003 SARS pandemic that the disciplined use of PPE, in particular N95 masks, and proper hand hygiene protected HCWs from getting infected.<sup>40</sup> To date there is no accurate data on the total number of HCW infected from COVID-19 but there are significant reports globally of human transmissions involving HCWs.<sup>16,41</sup> When managing patients who are suspected or positive COVID-19, we advocate for the use of face shield or goggles, masks, full body gown and gloves in line with WHO recommendations.<sup>6,39</sup>

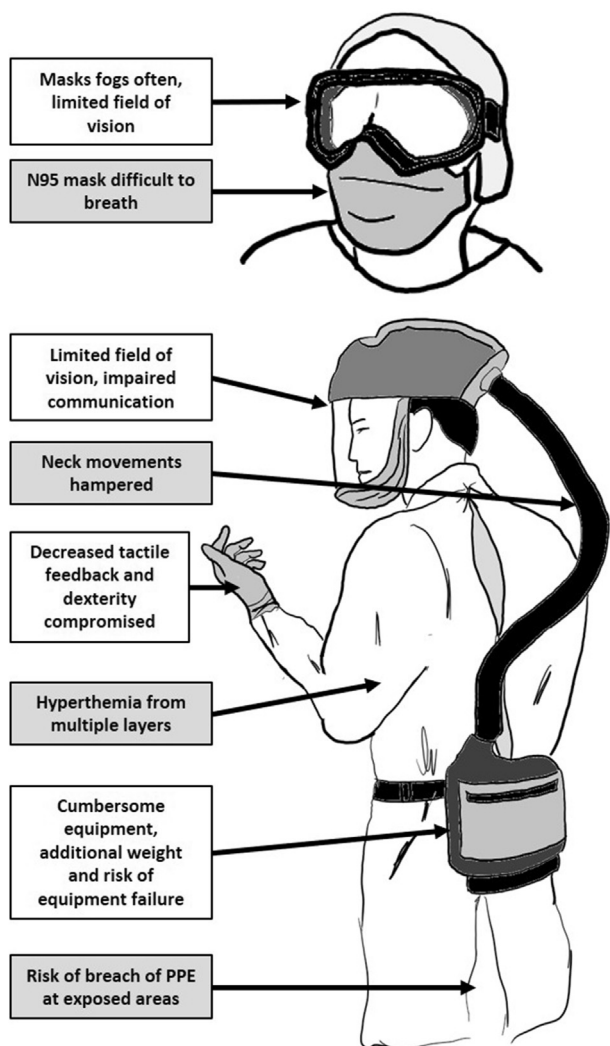
We worked together with our anaesthetists to develop a workflow for COVID-19 patients or suspected patients who undergo surgery.<sup>42</sup> There should be dedicated transfer routes, dedicated operating theatre equipment, negative pressure anteroom and induction rooms with positive pressure operating and preparatory rooms for laminar air flow.<sup>3,4,9,19,25,41</sup> For thoracic surgical patients who undergo aerosolizing

procedures and those that involve airway management such as intubation, bronchoscopy, tracheostomies, extubation, median sternotomy, pleural procedures, chest tube insertions and hand ventilation, standard PPE with N95 or FFP2 masks should be utilized.<sup>6,9,29,41–44</sup> Powered air-purifying respirators (PAPR) can be used as an alternative if available.<sup>7</sup> Staff not involved in the aerosolizing procedure should stay at least 2 m away and don N95 masks.<sup>25,42</sup> Non-essential staff should not be allowed into theatre and the number of staff involved in the case should be minimized.<sup>41,42</sup> The use of PAPR and PPE with N95 masks introduce additional challenges for the surgical team by limiting field of vision, neck movements, communication, tactile function and hand dexterity (Fig. 1).<sup>10,25</sup> At minimum, N95 masks should be used in addition to standard sterile surgical attire when doing such procedures. Disposable equipment should be utilized as far as possible.<sup>11,41,42</sup> Hand hygiene before and after procedures must be strictly enforced.<sup>25</sup> After the procedure, proper disinfection must be done of the OT and equipment cleaned separately before further utilization.<sup>11,25</sup>

### Intraoperative management

When performing thoracic surgery, electrosurgical instruments such as monopolar diathermies, advanced bipolar and ultrasonic dissectors should be placed on the lowest setting to minimize aerosolization. Smoke evacuators should also be used when diathermies are used.<sup>41,45</sup>

Previous studies have shown the possibility of aerosolization of blood borne viruses during laparoscopy.<sup>3,6,46</sup> This risk may apply to patients undergoing robotic assisted thoracoscopic surgery or video assisted thoracoscopic surgery of the mediastinum where carbon dioxide insufflation is



**Fig. 1 – Difficulties encountered with PPE and PAPR use.**

utilized. Although not yet seen with COVID-19, the use of air filter devices during the release of carbon dioxide insufflation should be considered.<sup>3,6,11,41</sup>

### Research activities and resident training

In the face of a new and unknown disease entity like COVID-19, open collaboration and global sharing of information between healthcare systems is our strongest weapon.<sup>47</sup> Research activities related to the pandemic should be encouraged and intensified during this period as a concerted response to the disease. Thoracic surgical research, where relevant to the ongoing pandemic and beneficial in advancing modalities of treatment may continue. Non-essential clinical trials and research should only continue if resources allow. With the aid of technology, global round table discussions, webinars and conferences should be freely encouraged to facilitate the exchange of information, ideas and treatment modalities.<sup>19</sup>

To balance trainee requirements, residents should continue to be exposed to the operating theatre even during

the outbreak. Manpower must be evenly distributed within the confines of segregation as residents continue to hone their clinical and operative skills.<sup>2,48</sup> With the reduction in elective load, opportunities will be decreased.<sup>6</sup> Residents should continue to maintain their skills using simulation where time and resources permit.<sup>48</sup> Conferences, educational courses and examinations that require travel should be postponed.<sup>6,48</sup> However, trainees should also continue to enhance their knowledge by attending webinars and through internet-based learning platforms.<sup>48</sup> Prolonged training might be a necessity if the pandemic becomes protracted and arrangements for indemnity made.<sup>6,48</sup>

In the initial stages, junior trainees should not be exposed to COVID-19 patients unnecessarily. However, as HCW infections, quarantine orders and fatigue sets in, opportunities for residents to step up into roles beyond their usual duties will arise. Residents as trainees and future specialists, must be prepared to be called upon during such times and sufficiently equip themselves to do so.<sup>48</sup> This calls upon senior physicians to undertake closer supervisory roles and in instances step down to help their juniors where necessary. A cohesive and united division makes for an easier time in the face of a pandemic.

### Ethical considerations

The management of COVID-19 patients during and after pandemics raises ethical considerations. The principles of nonmaleficence and beneficence must be carefully balanced to avoid unnecessary harm to patients yet resolve their issues in a timely fashion. A scenario from the SARS crisis reported a series of 6 infectious patients who developed barotraumatic pneumothorax. The team elected to conservatively manage them citing various logistical and infection control reasons.<sup>49</sup> This was criticized and argued that the risk of HCW infection from intubated patients is mitigated. In such instances, the principle of distributive justice may be invoked to rationalize treatment.<sup>3,47</sup> Due to the limitations in resources, conservative management may be adopted more widely than before, during a surge.<sup>29</sup> In extreme situations when operating theatres are converted to makeshift ICUs and ventilators are shared between patients, surgical intervention would be forced to cease and conventional modalities may become first-line therapy.<sup>9,15</sup> Deliberate efforts, including ethical decision making, must be taken to minimize resource utilization where appropriate.<sup>15</sup>

### Conclusion

As seen with COVID-19, in times of pandemics health care systems are prone to being overwhelmed and resources stretched. During such times, provision of basic healthcare is a challenging task. The key principles and measures that are summarized in Table 3 provide a framework encompassed by the tenets of planning of services, perioperative considerations, research activities, resident training and ethical consideration. These allow us to continue providing thoracic surgery services during and after an outbreak to infectious

**Table 3 – Summary table of key tenets and associated implementation measures.**

Key tenets	Implementation measures
Resource distribution and workflows	Pre-planning on an institution and national level Team segregation Geographical segregation Encourage telecommuting, social distancing Maintain healthy PPE and ventilator stockpiles
Outpatient clinics	Support for healthcare workers Restrict number of visitors Encourage teleconsultation Screening of all hospital visitors Screening of visits and rescheduling Maintain pre-operative consults
Patient transfers	De-isolation prior to transfer Maintain overview of hospital bed situation Strict criterion for transfer Outpatient reviews where possible
Inpatient management	Reduce inpatient stay Same day admissions Telemedical outpatient follow up Outpatient pre-operative workup Expanded screening criteria for thoracic patients Cohort thoracic surgery patients PPE training for staff
Prioritizing surgery	Triage and stratification of cases Postpone elective cases Retention of emergency cases Lung transplantation with extreme caution
Infection control measures in the operating theater	PPE and hand hygiene Operating theatre workflow for isolated patients PPE use for aerosolizing procedures with airway contact Physical distancing from procedure
Intraoperative management	Diathermies to lowest settings Smoke evacuators and air filter devices Minimize carbon dioxide insufflation
Research activities and resident training	Encourage pandemic related research Global sharing of information to tackle disease Even distribution of manpower Postpone conferences, courses, examinations Utilize online learning platforms Closer supervision of trainees
Ethical considerations	Conservative management to minimize resource utilization Safeguard nonmaleficence and beneficence Invoke distributive justice

and non-infectious patients. Having such measures in place can ensure patients who require surgery are not denied the necessary treatment. Though this article relates specifically to thoracic surgery, our principles may be applied to other surgical disciplines as well.

## Declaration of Competing Interest

None.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.surge.2020.07.001>.

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