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However, after adjusting for patient risk factors, surgical mortality was not different across regions of varying COVID-19 regional severity, suggesting that this finding was related to an inherently sicker patient population undergoing higher-risk surgeries, rather than impact from regional COVID-19 severity *per se*. Taken together, these findings support that the quality of care and safety of anaesthesia, surgery and perioperative medicine were maintained during the early phase of the pandemic.

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Declarations of interest

The authors declare no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.bja.2021.09.023>.

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Risk stratification of individuals undergoing surgery after COVID-19 recovery

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Editor—The COVID-19 pandemic has had an immense impact on surgical procedures worldwide. Since January 1, 2021, England and Wales have seen a 38.6% reduction in elective surgery, resulting in more than 1.5 million cancelled emergency and elective operations.¹ As elective surgery resumes, clinicians will be faced with an increasing number of individuals recovering from COVID-19.

Individuals undergoing surgery after recovery from COVID-19 are at increased risk of postoperative pulmonary complications and mortality.² There is also a significant association between hospitalisation with COVID-19 and persistent multiorgan dysfunction after recovery.³ As the time interval from diagnosis of SARS-CoV-2 infection to surgery increases, postoperative complications decrease progressively.⁴ When surgery takes place >7 weeks after diagnosis, 30-day mortality rates are somewhat similar to those of individuals with no preoperative SARS-CoV-2 infection (2.0% and 1.4%, respectively).⁴

In light of the above findings, the recent interprofessional consensus statement including the Royal College of Anaesthetists and the Royal College of Surgeons of England recommended that, for individuals with asymptomatic SARS-CoV-2 infection or resolved symptoms, elective surgery should not be scheduled within 7 weeks from the time of diagnosis.⁵ Individuals who were hospitalised, or those with persistent symptoms after COVID-19, may be at considerable risk of postoperative mortality, even when surgery is delayed for 7 weeks. In such cases, postponement beyond 7 weeks and a personalised plan for timing of surgery is recommended.⁵ However, there is currently little guidance for stratifying risk in these individuals before surgery. Therefore, deciding the optimal timing of surgery, based on the risk–benefit of disease progression vs delaying surgery for optimisation, remains challenging.

Given the risks after mild COVID-19 appear to be minimal, the major question that remains is: *How can we accurately risk-stratify individuals with prior hospitalisation or persistent symptoms who are scheduled for surgery?* Data are lacking, but one approach may be to evaluate the predictive value of biomarkers and physiologic derangements in individuals with ‘long COVID’, a term used to describe signs and symptoms that continue or develop beyond 4 weeks after COVID-19 diagnosis.

The predictive value of acute phase reactants during acute COVID-19 illness has been studied extensively, and there are emerging data that these reactants may remain elevated after COVID-19 recovery. D-dimer, ferritin, and C-reactive protein (CRP) are three such biomarkers that have been found to be persistently elevated 6–8 weeks after hospital discharge.⁶ In non-COVID-19 perioperative settings, CRP elevation is associated with postoperative complications; further studies are required to delineate the prognostic role of elevated CRP specifically after COVID-19 recovery.

Pulmonary fibrosis, impaired lung diffusing capacity, cardiac arrhythmias, ventricular dysfunction, and pulmonary hypertension are frequently observed after COVID-19 recovery.^{7,8} High-sensitivity troponin and N-terminal-proB-type natriuretic peptide may be elevated in individuals with long COVID, although this may reflect the hyperinflammatory response, rather than specifically indicating myocardial injury.⁹ The role of these cardiac biomarkers in long COVID remains to be elucidated. Similarly, persistently elevated inflammatory markers from the initial ‘cytokine storm’, such as interleukins and tumour necrosis factor- α ,¹⁰ may be responsible for diminished myocardial performance and, therefore, may have

prognostic value in long COVID. However, these markers are not commonly available in clinical practice.⁷

Other organ systems impacted substantially in individuals with long COVID include the neurologic, haematologic, renal, hepatic, and endocrine systems.¹¹ Memory loss, cognitive difficulties, thrombocytopenia, coagulation abnormalities, and impaired glucose metabolism have all been observed in individuals with long COVID.¹²

Further work is required to determine how these changes complicate recovery from surgery after COVID-19. Identification of measurements with prognostic importance should lead to refinement of predictive models to provide quantitative estimation of perioperative risk. We envisage an algorithm for preoperative risk stratification of recovered COVID-19 patients, whereby individuals are first classified on the basis of symptoms and hospitalisation. Those with asymptomatic disease or resolved symptoms are not considered to be at significantly increased perioperative risk as a result of recent COVID-19. Therefore, these individuals can proceed to elective surgery 7 weeks from COVID-19 diagnosis. Patients who were hospitalised, or those with persistent symptoms, should undergo targeted organ-specific assessment using a combination of echocardiography, lung function tests, and aforementioned biomarkers. With clarification of the importance of these biomarkers, better quantification of perioperative risk may then be weighed up against the risk of delaying surgery (and disease progression), assisting optimal timing of surgery.

In conclusion, further research is required to evaluate biomarkers and physiologic abnormalities in patients after COVID-19 recovery, and how these may predict postoperative outcomes. Future use of these variables for risk stratification may not only assist with deciding the optimal timing of surgery, but also with informed consent and shared decision-making.

Declarations of interest

The authors declare that they have no conflicts of interest.

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