benefits of iNO in inhibiting early-stage viral replication are unlikely to have benefited patients in whom iNO was administered 12 (8–18) days after ICU admission.

As with all retrospective analyses, we acknowledge the possibility of residual confounding, and that results are associative. The small number of COVID-19 related ARDS patients included also warrants caution in interpreting the findings. CT imaging was not performed on all patients because of clinical instability or lack of a clear indication; thus, the presence of major emboli may have been missed in some patients. Alternatively, lack of identification by CT does not exclude the presence of multiple pulmonary microthrombi contributing to increased pulmonary vascular resistance and right heart dysfunction. Echocardiography was not performed systematically to assess impact on cardiac anatomy and function, but NT-BNP levels were significantly elevated and raised pulmonary pressures were commonplace findings when measured. NT-BNP and D-dimer values were not routinely collected in ARDS patients before the COVID-19 pandemic so comparisons cannot be made.

In summary, more than half of patients with refractory hypoxaemia secondary to COVID-19 ARDS did not show an increase in PaO_2/FiO_2 ratio in response to iNO. This response was much lower compared with a cohort with ARDS not related to COVID-19. Further work is required to ascertain if this lack of response to iNO is diagnostic for degree of pulmonary thromboembolism.

Authors' contributions

Study design: NA
Data collection: AL, CM, RS, SB
Statistics: NA
Drafting manuscript: NA
Finalising manuscript: MS, NA

Declarations of interest

The authors declare that they have 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.2020.10.011.

References

1. Gebistorf F, Karam O, Wetterslev J, Afshari A. Inhaled nitric oxide for acute respiratory distress syndrome (ARDS) in children and adults. *Cochrane Database Syst Rev* 2016; **6**: CD002787
2. Bellani G, Laffey JG, Pham T, et al. Epidemiology, patterns of care, and mortality for patients with acute respiratory distress syndrome in intensive care units in 50 countries. *JAMA* 2016; **315**: 788–800
3. Helms J, Tacquard C, Severac F, et al. High risk of thrombosis in patients with severe SARS-CoV-2 infection: a multicenter prospective cohort study. *Intensive Care Med* 2020; **46**: 1089–98
4. Menter T, Haslbauer JD, Nienhold R, et al. Postmortem examination of COVID-19 patients reveals diffuse alveolar damage with severe capillary congestion and variegated findings in lungs and other organs suggesting vascular dysfunction. *Histopathology* 2020 May 4; **77**: 198–209
5. Hedenstierna G, Chen L, Hedenstierna M, Scaramuzzo G. Treatment of COVID-19 by inhaled NO to reduce shunt? *Am J Respir Crit Care Med* 2020; **202**: 618
6. Tavazzi G, Marco P, Mongodi S, Dammassa V, Romito G, Mojoli F. Inhaled nitric oxide in patients admitted to intensive care unit with COVID-19 pneumonia. *Crit Care* 2020; **24**: 508
7. Patel BV, Arachchillage DJ, Ridge CA, et al. Pulmonary angiopathy in severe COVID-19: physiologic, imaging and hematologic observations. *Am J Respir Crit Care Med* 2020; **202**: 690–9
8. Chen L, Liu P, Gao H, et al. Inhalation of nitric oxide in the treatment of severe acute respiratory syndrome: a rescue trial in Beijing. *Clin Infect Dis* 2004; **39**: 1531–5
9. Gattinoni L, Coppola S, Cressoni M, Busana M, Rossi S, Chiumello D. Covid-19 does not lead to a "typical" acute respiratory distress syndrome. *Am J Respir Crit Care Med* 2020; **201**: 1299–300
10. Gattinoni L, Chiumello D, Caironi P, et al. COVID-19 pneumonia: different respiratory treatments for different phenotypes? *Intensive Care Med* 2020; **46**: 1099–102
11. Hedenstierna G, Chen L, Hedenstierna M, Lieberman R, Fine DH. Nitric oxide dosed in short bursts at high concentrations may protect against Covid 19. *Nitric Oxide* 2020; **103**: 1–3

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Response of US hospitals to elective surgical cases in the COVID-19 pandemic

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Keywords: COVID-19; elective surgery; emergency management; healthcare policy; pandemic response

Editor—In anticipation of patients with coronavirus disease 2019 (COVID-19) overwhelming hospital resources, institutions and policymakers in the USA advocated a strategy to decrease surgical and interventional procedures rapidly in early 2020.[1,2] The downside has been a delay in treating patients and substantial revenue losses for many institutions. However, the precise timing, scale, and heterogeneity of US surgical case volume reduction and resumption of surgical activity have not yet been described. Understanding the response of US institutions to the first wave of COVID-19 will be critical to adjust hospital policies for upcoming or ongoing second waves in many places.

We did a nationwide analysis using data from the Multicenter Perioperative Outcomes Group, a registry of surgical procedures from academic and private hospitals across 21 US states.[3] Briefly, electronic health record data for all patients undergoing surgical procedures from each participating institution are aggregated at the data coordinating centre each month after rigorous data quality validation.[4] Between January 1, 2019 and May 31, 2020, all surgical cases at 33 health systems were totalled weekly to achieve maximum timing precision without influence by standard weekend reductions in case volume. Weekly case volumes were analysed via segmented regression and compared between 2019 and 2020.

We analysed 1 979 445 cases and observed a sharp decline in procedures during the week of March 16, 2020 (Fig 1), as COVID-19 diagnoses began to increase nationally.[5] We observed a nadir in case volumes the week of April 6. During the week of April 6, we observed a 71% reduction compared with the same week in 2019. Between March 16 and May 31, the median per-week reduction in case volume relative to the same weeks in 2019 was 57% (inter-quartile range: 39–67%) (Fig 1). This reduction primarily reflected elective cases (10 237 cases per week in 2020 *vs* 27 122 in 2019; 62% reduction; paired Wilcoxon rank-sum test; $P<0.001$), whereas the volume of emergent cases decreased to a lesser extent (1248 *vs* 1350; 8% reduction; $P=0.024$), as observed for other medical conditions.[6]

We also observed significant heterogeneity in case volume reductions across institutions, with *per-institution* median weekly reductions ranging from 33% to 72% (intra-class correlation coefficient: 0.53; 95% confidence interval: 0.45–0.61; *F*-test $P<0.001$). The decrease in case volumes was followed by a rapid increase such that by May 31, surgical case volumes were within 20% of case volumes at the same time in 2019 (Fig 1).

To summarise, an early rapid decrease in US surgical case volumes beginning mid-March 2020 was followed by a similarly rapid increase towards baseline beginning by mid-April while the pandemic was active and the numbers of COVID-19 cases were rising quickly. Case volume reductions varied significantly by institution. Important lessons can be learned from these observations. The global recommendations to cancel elective surgeries at the beginning of the pandemic regardless of the local situations of COVID-19 cases and hospitalisation should probably be more gradually implemented and adjusted based on local situations. The rapid increase in number of surgical procedures while the pandemic was very

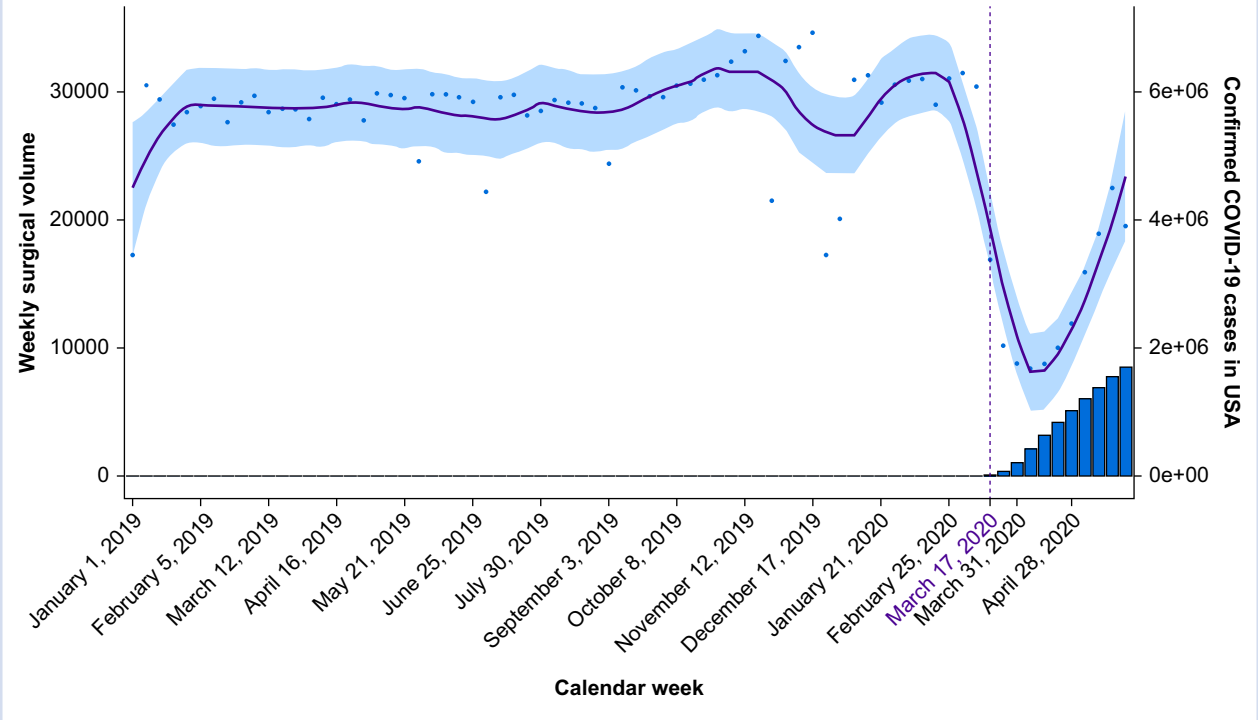

Fig 1. Weekly surgical volume at 33 US hospitals and cumulative number of COVID-19 cases in the USA from January 1, 2019 to May 31, 2020.

active certainly illustrates a perception of inappropriate adjustments of elective case volume by many local situations. The need for more local adjustments is further illustrated by the homogeneous timing of changes in surgical volumes across the country whereas the COVID-19 case surges were more temporally dispersed across the country.

Further analysis will be necessary to understand the specific factors that influenced the local and regional heterogeneity and the potential impact on patient outcomes to further inform public health response to future waves. We suggest a more locally and temporally adjusted response from US hospitals depending on COVID-19 hospitalisation trends to prevent avoidable cancellation of surgical cases, which might unnecessarily impact patient prognosis and hospital financial security.

Declarations of interest

The authors declare that they have no conflicts of interest.

References

1. COVIDSurg Collaborative. Global guidance for surgical care during the COVID-19 pandemic. *Br J Surg* 2020; **107**: 1097–103
2. Centers for Medicare & Medicaid Services. *CMS releases recommendations on adult elective surgeries, non-essential medical, surgical, and dental procedures during COVID-19 response 2020*. Available from, https://www.cms.gov/newsroom/press-releases/cms-releases-recommendations-adult-elective-surgeries-non-essential-medical-surgical-and-dental. [Accessed 7 August 2020]. accessed
3. Sun E, Mello MM, Rishel CA, et al. Association of overlapping surgery with perioperative outcomes. *JAMA* 2019; **321**: 762–72
4. Colquhoun DA, Shanks AM, Kapeles SR, et al. Considerations for integration of perioperative electronic health records across institutions for research and quality improvement: the approach taken by the Multicenter Perioperative Outcomes Group. *Anesth Analg* 2020; **130**: 1133–46
5. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect Dis* 2020; **20**: 533–4
6. De Filippo O, D'Ascenzo F, Angelini F, et al. Reduced rate of hospital admissions for ACS during Covid-19 outbreak in Northern Italy. *N Engl J Med* 2020; **383**: 88–9

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Respiratory personal protective equipment for healthcare workers: impact of sex differences on respirator fit test results

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Keywords: COVID-19; fit testing; healthcare worker; mask respirator; personal protective equipment; SARS-CoV-2; sex difference; systemic discrimination

Editor—Adequate personal protective equipment (PPE), in particular respiratory protective equipment, is a core requirement for healthcare workers during infectious disease pandemics. Global shortages of PPE during the coronavirus disease 2019 (COVID-19) pandemic have put healthcare workers at risk and likely led to preventable infection and deaths.[1] In many countries, respirators have been rationed to high-risk areas and aerosol-generating procedures because of cost and shortages.[2] In the UK, filtering face piece class 3 (FFP3) respirators are the respiratory PPE of choice and provide protection from aerosolised viruses, such as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), but only when they are properly fitted to the wearer. Thus, staff must pass a fit test to safely use respirators.[3]

The media has highlighted anecdotal evidence about the inadequacies of PPE for females.[4] The majority of healthcare staff are female[1,4]; however, respirators are modelled on white males, which means they are less likely to fit and, therefore, less likely to protect female staff, who tend to have smaller faces.[4,5] To our knowledge, there has been no published evidence that women are less likely to pass fit testing.

After approval from our Trust Information Governance Department and a waiver of individual participant consent, we analysed 1049 fit tests conducted at our institution during the COVID-19 pandemic; 813 (77%) in females and 236 (23%) in males. Staff underwent qualitative fit testing with either sweet or bitter spray.[3] Sex and gender data were not recorded during fit testing; therefore, gender was inferred from the names of staff members, and sex inferred from the gender. Females were less likely to fit FFP3 respirators with an 18.2% fail rate *vs* 9.7% for males ($P<0.01$, χ^2 test; Table 1).