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Recovery after critical illness in COVID-19 ICU survivors

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Editor—Coronavirus disease 2019 (COVID-19) has placed an enormous strain on ICUs in the UK with mortality rates of about 40%.[1] Invasively ventilated ICU survivors have frequently required prolonged critical care, but to date there have been limited reports on recovery and rehabilitation in these patients. Case series have mainly focused on all hospitalised patients, including patients with less severe disease.[2,3] Studies in critically ill individuals have been limited to functional status assessments or have focused on the residual radiological features in these patients.[4,5]

Our dedicated ICU COVID-19 follow-up clinic has assessed all patients cared for during the first wave of the UK COVID-19 pandemic. We report our findings for invasively ventilated patients from this multidisciplinary assessment of patient recovery and rehabilitation. Our institution's research and innovation department determined that this project did not require ethical approval. Information governance safeguards were approved by our institution's Caldicott guardian.

Face-to-face review was undertaken by a critical care consultant with input from physiotherapists, occupational therapists, dieticians, and critical care nurses. Patients completed quality of life, anxiety, depression, and post-traumatic stress surveys by telephone before review, and chest radiograph, pulmonary function tests, and measures of muscle strength in the clinic. Subjective and objective measures of dyspnoea were recorded.

Between March 17 and May 31, 2020, 110 patients were admitted to our ICU with confirmed or probable COVID pneumonitis: 60/110 (54.5%) were invasively ventilated, of whom 40 (66.7%) survived to ICU discharge and 38 (63.3%) were discharged home. Of these, 36/38 patients (95%) attended the follow-up clinic. Detailed patient characteristics and ICU care can be found in Supplementary Table S1.

Neuromuscular blocking agent (NMBA) infusion was used in 26/36 (72%) patients; 15/36 (42%) required prone positioning; 20/36 (56%) required tracheostomy to facilitate weaning from the ventilator; and 2/36 (6%) required transfer to another unit for extracorporeal membrane oxygenation (ECMO). The median length of stay in our ICU was 25 (inter-quartile range [IQR], 14–34) days. Patients were seen in the clinic 10.9 (standard deviation [SD], 2.4) weeks after hospital discharge. Table 1 provides an overview of the rehabilitation and recovery metrics assessed.

The majority of patients (83%) had complete resolution of their radiographic findings and normal oxygen saturations both at rest and after exertion in a 60-s sit-to-stand test. Pulmonary function tests identified a mild restrictive defect with normal carbon monoxide transfer coefficient (KCO). However, there was a marked reduction in grip strength measurements in comparison with a healthy population reference range of similar age and sex.[6] From a functional perspective, scores were reduced in all Short Form (SF)-36 domains with the

Table 1 Outcomes of invasively ventilated patients who attended follow-up clinic. Data are given as *n* (%) or mean (SD) unless otherwise stated. CPAx score comprises 10 commonly assessed components of physical ability, each graded on a 6-point scale from 0 (complete dependency) to 5 (complete independence). Borg rating of perceived exertion: 0 to 10 scale (where 0=rest, 10=extreme exertion). SF-36 is a 36 item self-reporting tool which measures both physical health (physical function, physical role function, bodily pain, and general health) and mental health (vitality, social function, emotional function, and mental health). Each domain is scored from 0 (poor health) to 100 (excellent health). HADS is a 14-item self-reported screening tool each item is rated 0–3 with total scores of 11+ associated with clinical anxiety and depression. PTSS-14 is a 14-item self-report screening tool; each item is rated 1 (never) to 7 (always) with a total score ranging from 14 to 98. CPAX, Chelsea Critical Care Physical Assessment Tool; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; HADS, Hospital Anxiety and Depression Scale; KCO, carbon monoxide transfer coefficient; PTSS-14, post-traumatic stress symptoms 14; SD, standard deviation; SF-36, Short Form-36: TLCO, diffusion capacity for carbon monoxide.

	All patients (*N*=36)	Male (*n*=23)	Female (*n*=13)
Spirometry and lung function			
FEV_1 (% predicted) (*n*=35)	80.4 (13.9)	77.1 (12.9)	85.8 (14.4)
FVC (% predicted) (*n*=36)	78.1 (13.2)	75.8 (12.3)	75.9 (14.4)
FEV_1/FVC (%) (*n*=35)	81.5 (8.9)	79.5 (9.5)	79.5 (6.9)
TLCO (% predicted) (*n*=31)	67.4 (14.4)	65.9 (15.4)	71.1 (15.4)
KCO (% predicted) (*n*=31)	95.5 (18.2)	95.8 (18.2)	94.8 (18.2)
Chest radiograph report			
Complete resolution, *n* (%)	30 (83)	18 (78)	12 (92)
Incomplete resolution, *n* (%)	6 (17)	5 (22)	1 (8)
Assessment of physical function			
Grip strength (kg; mean of 3 measurements) (*n*=31)	21.4 (9.7)	25.6 (9.3)	15.5 (7.2)
CPAx score (*n*=31)	46.8 (2.9)	46.8 (2.8)	46.8 (3.3)
Subjective and objective assessment of breathlessness			
Number of sit-to-stands completed in 60 s (*n*=28)	19.0 (8.4)	20.3 (7.2)	16.5 (10.0)
SpO_2 before exertion, *n* (%) (*n*=28)	97 (0)	97 (0)	98 (0)
SpO_2 immediately after exertion, *n* (%) (*n*=28)	96 (0)	96 (0)	96 (0)
SpO_2 5 min after exertion, *n* (%) (*n*=28)	97 (0)	97 (0)	97 (0)
Borg scale before exertion (*n*=28)	0.5 (1.2)	0.3 (0.8)	1.0 (1.5)
Borg scale immediately after exertion (*n*=28)	4.6 (2.2)	4.7 (2.3)	4.5 (2.1)
Borg scale 5 min after exertion (*n*=28)	0.7 (1.2)	0.6 (1.2)	0.9 (1.2)
Quality of life, depression and post-traumatic stress			
SF-36 Physical functioning (*n*=29)	54.5 (29.9)	58.0 (28.6)	46.7 (32.9)
SF-36 Role limitations owing to physical health (*n*=29)	31.0 (41.5)	37.5 (45.5)	16.7 (28.0)
SF-36 Role limitations owing to emotional problems (*n*=29)	43.7 (49.7)	53.4 (50.0)	22.2 (44.1)
SF-36 Energy/fatigue (*n*=29)	46.9 (27.7)	53.0 (25.9)	33.3 (28.1)
SF-36 Emotional well-being (*n*=29)	73.3 (25.5)	81.1 (18.3)	56.0 (31.6)
SF-36 Social functioning (*n*=29)	62.2 (34.3)	67.6 (30.7)	50.1 (40.5)
SF-36 Pain (*n*=29)	50.8 (30.2)	53.0 (30.2)	45.9 (40.4)
SF-36 General health (*n*=29)	51.2 (24.3)	54.0 (24.3)	45.0 (24.5)
HADS Anxiety Score ≥11, *n* (%) (*n*=30)	6 (20)	2 (10)	4 (31)
HADS Depression ≥11, *n* (%) (*n*=30)	7 (23)	2 (10)	5 (38)
PTSS14 ≥45, *n* (%) (*n*=17)	8 (57)	3 (33)	5 (63)

largest reductions in role limitations caused by impairment in physical health. We found that 20% of patients who responded reported clinically significant anxiety and depression symptoms and 57% reported clinically significant post-traumatic stress symptoms.

Our findings offer insight into the early recovery of invasively ventilated COVID-19 patients. Respiratory findings were similar to early follow-up reports of other acute respiratory distress syndrome (ARDS) survivors, in which patients often display a mild restrictive pattern on spirometry and compromised diffusion capacity (TLCO).[7] We suggest that respiratory muscle weakness is the major contributor to these abnormalities in view of the radiological findings, marked reduction in grip strength, and patient-reported physical limitation and dyspnoea. Anecdotally, our experience has been that intubated patients with COVID-19 frequently desaturate during spontaneous breathing trials and sedation weaning. This has led to prolonged use of neuromuscular block, increased sedation regimes, and frequent use of prone positioning, which may have contributed to the muscle weakness observed.

A Swiss study[8] of critically ill patients recovering from COVID-19 who were followed up at 4 months reported marked desaturation (to 90%) during 6 min walk tests. We did not observe this phenomenon during sit-to-stand exercises; this is surprising as only 70% of the Swiss cohort had been invasively ventilated, and they were seen after a longer period of recovery (4 *vs* 2–3 months) and had better spirometry results. The differences may reflect the different exercise regimes used.

Our patients reported marked reduction in all SF-36 domains, in particular in role limitation caused by impairment in physical health. This pattern is well established in ARDS survivors,[9] and is more marked in our population possibly as a result of the earlier timing of follow-up and perhaps the expectations of our patients, who were young and in good physical health before their critical illness.

Post-traumatic stress syndrome is a recognised phenomenon after critical illness with rates of 29% amongst ARDS survivors at 1 yr.[7] Our rate of 57% is much higher, which is concerning. This may in part reflect our small sample size, response bias, and the earlier timing of our follow-up. COVID-19 ICU survivors will need continued follow-up and support to characterise these psychological sequelae and to help mitigate the effects of this significant life event.

'Long Covid' has been used to describe symptoms in people reporting long-term effects after COVID-19, but we would urge caution in applying this diagnosis to ICU survivors who may simply be experiencing the symptoms and recovery typical of many ARDS survivors.

We have observed significant physical weakness in critically ill patients recovering from COVID-19, highlighting the need for ongoing physical rehabilitation in this patient group. Detailed analysis of both ICU care and follow-up of COVID-19 patients may allow identification of the most favourable management strategies of patients with severe COVID-19 in order to mitigate long-term sequelae.

A limitation of this study is that it is a single-centre review; therefore, our findings may not reflect the outcomes of patients cared for in other ICUs. Furthermore, the number of survivors in whom we report data is relatively small. However, our admission characteristics and detailed descriptors of ICU stay allow other units to make a comparison with their own data. Our results may assist in health service planning and ongoing care and support requirements for an ever-increasing number of mechanically ventilated COVID-19 survivors.

Declarations of interest

GK is an editorial fellow of *British Journal of Anaesthesia*. No other conflicts of interest exist.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2021.03.005.

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Rationing oxygen use during total intravenous anaesthesia: a proportionate response?

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Editor—We read with interest Hall and Chakladar's[1] comment on the recent study by Zhong and colleagues[2] of the environmental and economic impacts of fresh gas flow (FGF) during total i.v. anaesthesia. Their concern