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Clinical guide for the management of critical care for adults with COVID-19 during the Coronavirus pandemic

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Contents

1 Introduction

This clinical guidance provides contemporary information for practising clinicians caring for critically ill adult patients with COVID-19. Whilst many of these patients will be cared for on intensive care units, some patients receiving continuous positive airways pressure (CPAP) and/or non-invasive ventilation (NIV) may be cared for on specialist respiratory wards. Version 4 updates the previous FICM and ICS guideline published on 22nd June 2020.

This document will be updated at regular intervals during the COVID-19 pandemic. Please always refer to the most up-to-date version, which will be available on the four organisations (Association of Anaesthetists, FICM, ICS, Royal College of Anaesthetists) hub. This can be found here: https://icmanaesthesiacovid-19.org

This guide summarises the clinical characteristics of COVID-19 and offers advice on:

- Dealing with 'surge' including mutual aid
- COVID-19 clinical characteristics and specific treatments
- Clinical decision-making
- Management of respiratory failure
- Management of non-respiratory organ failure

This revised version contains important additions relating to:

- Antivirals
- Steroid therapy
- Co-infection with influenza
- Blood and thromboprophylaxis
- Acute Kidney Injury
- Neurological manifestations and management of ICU acquired weakness
- Gastrointestinal manifestations

The COVID-19 pandemic has placed an extraordinary burden on critical care that has been met through the creation of surge capacity within and beyond hospital walls. Many non-specialist healthcare providers have supported critical care specialists to provide care. Staff safety and wellbeing are crucial as the need to respond to the pandemic continues through the winter. Maintenance of this sustained response in parallel with continuation of elective services and predictable winter pressures will challenge the resilience of critical care provision.

Monitoring and regular reporting of care and outcomes in the context of COVID-19 has been established by ICNARC through accelerated data submission to the Case Mix Programme, the national clinical audit for adult critical care. ICNARC has also developed the ability for direct data entry of a reduced dataset for critically ill patients not on a critical care unit, e.g. respiratory wards. Please contact ICNARC to ascertain how to capture data on this important group of patients that are critically ill with COVID-19. Analyses of Case Mix Programme data will inform future versions of this guidance.

The effectiveness of many interventions in the context of COVID-19 is currently uncertain. This guide is informed by emerging information about COVID-19 management as well as best available evidence from non-COVID-19 patients. Multi-centre clinical trials are currently underway in patients with COVID-19 and will inform future versions of this guidance.

COVID-19 related clinical trials are important to the rapid development of an evidence base for this new disease and should be supported. The only solution to the threat posed by the virus is to develop effective preventative and therapeutic interventions through high-quality research. Clinicians' firmly held beliefs in the effectiveness or otherwise of interventions, in the absence of reliable evidence (so-called "lack of equipoise"), are an obstacle to such progress.

The list of prioritised trials for COVID-19, including several in which critical care patients could be recruited (such as REMAP-CAP, ISARIC-4C, GenoMICC and 'RECOVERY-respiratory support'), can be found here**.**

The guideline development group members are listed below:

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2 Dealing with surge

Surge Capacity: defined as increases in patient numbers where demand exceeds baseline capacity

Mutual Aid: defined as the gift, loan or exchange of resources for mutual current or future benefit.

Consideration should be given to the use of mutual aid in line with regional and national surge plans. Examples of "resources" would include patient transfers (transferring care to reduce the local clinical burden) and staff, equipment, consumable items or drugs. The COVID-19 pandemic has highlighted the importance of collaboration and material support between intensive care units. Clinicians should not hesitate to seek advice and support, e.g. patient transfers, loan of equipment drugs and disposables, from colleagues in adjacent units when they feel that their own clinical experience or their local resources are stretched.

Supporting critical care surge capacity requires different ways of working extending to:

- Location
  - Care of the critically ill being delivered in existing high acuity care areas within the hospital or purpose-built structures such as the NHS Nightingale facilities.
  - Increased requirement for inter-hospital transfers within regions, **'mutual aid'** within critical care networks and where necessary between regions. Planning for mutual aid within and between networks is an essential facet of planning. This should include triggers for when mutual aid will be required and the principles underpinning the decision making.
- People
  - Non-specialists delivering critical care.
  - Individuals and teams working in personal protective equipment (PPE).
- Equipment
  - Working with unfamiliar equipment and the associated training burden.
- Consumables
  - Managing a greatly increased demand for materials such as drugs, haemofilters, PPE and oxygen
  - See also: Clinical guide for the management of surge during the coronavirus pandemic: rapid learning.
- Decisions
  - Careful use and prudent allocation of resources, and learning from others' experiences working within the clinical and ethical constraints imposed by high demand and finite resources (see Section 4: Clinical decision-making).
  - Hospital systems should undertake advance planning to identify triggers for when additional staff and beds are made available to critical care. This will need to include triggers for sequential reduction in elective activity and should dovetail into the activities of COVID-Secure facilities including the use of the independent sector. Further advice on staffing levels and other workforce issues under surge conditions be found here: https://www.england.nhs.uk/coronavirus/workforce/

The safety and welfare of staff are essential if critical care provision is to remain resilient in the face of the demands of a sustained pandemic and should include:

- PPE guidance: PHE guidance
- Sustainable staffing patterns and rotas
- Attention to staff physical wellbeing, rest, diet and physical activity
- Attention to the psychological wellbeing of staff, particularly in relation to concerns about personal safety and responsibility (difficult clinical decision-making)
- Attention to the stresses on individuals working outside their usual scope of practice, e.g. non-specialist clinicians looking after critical care patients.
- Attention to the stresses on patients, relatives and staff due to restrictions on hospital and ICU visiting, particularly around end-of-life.

3 Clinical characteristics and specific treatments

SARS-CoV-2 infection causing COVID-19 may manifest as:

- Acute severe (15%) /critical illness (5%):
  - Acute hypoxemic respiratory failure.
  - Non-respiratory organ dysfunction including:
    - cardiovascular
    - renal
    - cardiac
    - neurological
    - hepatic
    - gastrointestinal (less common)
  - Arterial, venous and pulmonary thromboembolism
  - Hyper-inflammation syndromes
- Risk factors for worsened clinical outcomes in hospitalised patients:
  - Age: over 50, substantial risk over 70
  - Male sex
  - Obesity
  - Minority ethnic – particularly Asian and Black
  - Socio-economic deprivation
  - Comorbidities: cardiovascular disease, diabetes, chronic non-asthma respiratory disease, cancer, chronic kidney disease, chronic liver disease, chronic neurological disorder including dementia and chronic immunosuppression.

Diagnosis

- SARS-CoV-2 RNA Reverse Transcriptase - Polymerase Chain Reaction (RT-PCR)
  - From lower respiratory tract samples if possible
  - Beware false negative upper airway sample if clinical picture is typical
  - Consider co-infection with other respiratory pathogens
- Diagnostic imaging
  - Chest radiograph (CXR): bilateral patchy shadowing
  - Computerised Tomogram (CT) chest:
    - May help establish the diagnosis if there is uncertainty
    - May demonstrate large or small/multiple pulmonary thrombi/emboli
- Laboratory findings
  - Common laboratory findings include:
    - Low lymphocyte count
    - Normal Procalcitonin
    - Creatinine Kinase - elevation = myositis/myocardial involvement
    - Troponin - elevation = myocardial involvement (interpret with caution when renal function abnormal)
  - Severity of illness markers (not all necessary):
    - Elevated D-dimers
    - Elevated Troponin/Brain Natriuretic Peptide (BNP)
    - Elevated Ferritin
    - C-Reactive Protein (CRP) - rising CRP may indicate bacterial infection or disease progression. Rising Procalcitonin may indicate bacterial infection.

Management

Supportive care is the mainstay of COVID-19 management.

Anti-viral therapy

- Preliminary data from the WHO Solidarity trial suggest that there is no benefit from Remdesivir administration in critically ill patients.
- There is no evidence to support stopping therapy in patients who are already receiving Remdesivir.
- Updated guidance on Remdesivir therapy is available here.

Steroid therapy

- The RECOVERY trial supports administration of dexamethasone 6 mg once per day (enterically or intravenously) for 10 days. This reduced deaths:
  - in ventilated patients from 41.4% to 29.3%
  - in patients receiving oxygen only, from 26.2% to 23.3%
  - no benefit (possible harm) in those patients who did not receive oxygen.
- 'Meta-analysis of data from seven clinical trials recruiting critically ill patients with COVID-19 suggests both dexamethasone and hydrocortisone (50 mg intravenously every 6 hours for seven days) reduce all-cause mortality at 28 days, but there are currently insufficient data to support the use of methylprednisolone.
- When patients require corticosteroids for other indications (either at replacement doses for known adrenal insufficiency or as a treatment for another underlying condition such as asthma or Chronic Obstructive Pulmonary Disease (COPD)), they should **not** be withheld.

Other Anti-SARS-CoV-2/COVID-19 therapies should only be administered within the context of a nationally approved trial. COVID-19 related clinical trials should be supported to enable the rapid development of an evidence base for this new disease.

Routine antibiotics

- Antibiotic adminstration is **not** recommended for uncomplicated COVID-19.

COVID-19 and other infections

- Careful attention to antimicrobial stewardship is important
- Prevalence of both bacterial and fungal infection rises with time on ICU.
- Antibiotics should be considered if there is suspected bacterial super-infection.
- Antifungals should be considered in patients not responding to antibacterial treatment, who are known or strongly suspected to have fungal infection. Consider Galactomannan/ ß-D-glucan testing if available.
- There is limited information available on interactions between seasonal influenza and COVID-19:
  - PHE analysis of data from the latter part of the 2019-20 influenza season in England found the risk of testing positive for SARS-CoV-2 was 68% lower among influenza positive cases, suggesting possible pathogenic competition between the two viruses
  - Patients infected with both viruses had a risk of death 5.92 (95% CI 3.21-10.91) times greater than among those with neither influenza nor SARS-CoV-2, suggesting possible synergistic effects in coinfected individuals.
  - The odds of ICU admission, ventilator use or death was greatest among coinfected patients when compared with patients with either SARS-CoV-2 or influenza infection.
  - Therefore, where possible, COVID-19 and influenza should be cohorted separately.

Treatment of other conditions in the context of COVID-19

- Take care not to neglect treatment of exacerbation of any underlying conditions, e.g. heart failure, COPD, diabetes.
- Consider other possibilities in the differential diagnosis for patients with possible COVID-19.

Impact of non-steroidal anti-inflammatory drugs (NSAIDs), ACE-inhibitors and Angiontensin II receptor blockers (ARBs) on COVID-19

- Where patients are already taking NSAIDs, ACE-inhibitors and ARBs for other conditions, **continuing treatment** is recommended by national and international bodies, including Renal Association UK, European Renal Association, the European Society of Cardiology and European Medicines Agency.
- There is no evidence that the acute use of NSAIDs causes an increased risk of developing COVID-19 or of progressing to more severe COVID-19.

4 Clinical decision-making

General comments

- The principles of intensive care decision-making are the same whether the patient has COVID-19 or any other condition.
- All patients should be treated respectfully and equitably, and should receive the best available care. Careful attention should be given to ensuring that any processes put in place to guide decision making do not inadvertently result in discrimination (unjust or prejudicial treatment) against patients with particular characteristics.
- Decisions should be consistent with established and accepted ethical and legal frameworks within the NHS and ideally occur via shared decision-making with patients, or, for patients assessed as lacking capacity, via Best Interests Processes (England and Wales), Common Law (Northern Ireland) or Least Restrictive Options by reference to the principles in the Adults with Incapacity Act (Scotland).
- Any decisions about treatment limitations, including treatment escalation plans (TEPs) and "do not attempt cardio-pulmonary resuscitation" (DNACPR) decisions, should never be made on a blanket basis and should be made in consultation with the patient/significant others.
- Patients should never be treated differently because of anticipated future pressures. It is important to focus on current clinical demands and available resources across regional and national critical care networks.
- Doctors should consider national guidance about clinical decision making from the DHSC, NHS-E/I (or equivalent in the devolved nations), GMC, NICE and professional bodies, including guidance specific to the current pandemic.

- Assess what care is likely to provide benefit to the patient, taking into account the best available evidence on factors that predict this and applying it to the specific situation of the patient being treated.
- Decision support tools, refined in the context of COVID-19, are available (NICE pathway) and can help guide these discussions and decisions. As more evidence and experience of managing COVID-19 becomes available, these tools may be refined further.

Referral and admission to intensive care or palliative care

- **Treatment escalation plans (TEP)** should be discussed with patients, and/or their relatives, at the first opportunity and be clearly documented. TEPs should take account of the person's values and of the goals of treatment.
- **Referral** for consideration of admission to ICU should be considered carefully by a senior clinician, using current guidance, e.g. NICE pathway, local and national guidelines, as an aid.
- The **decision to admit to intensive care is the responsibility of the intensive care consultant.** When an intensive care consultant is not immediately available, and a time-critical decision is required, another senior clinician with knowledge of intensive care interventions and outcomes should decide in the best interests of the patient.
- Decisions should be discussed with the patient, when they have the capacity to make decisions, or next of kin, personal representative, Lasting Power of Attorney (for health and welfare) or Independent Mental Capacity Advocate (IMCA) or utilising relevant arrangements as determined by each devolved nation's legal framework.
- Ensure that all discussions and decisions are clearly documented by the referring or ICU team as appropriate.
- When there is potential or actual disagreement, a clinical ethics panel should be rapidly available, at least on a regional basis, and consulted.

Treatment decisions

- All patients treated by intensive care services should have a named intensive care consultant responsible for their care and treatment decisions. Clinical handovers between responsible consultants should follow usual practice guidelines.
- The intensive care consultant may delegate decision making and interventions to other members of the team, but retains overall responsibility for the treatment of the patient.
- Good practice in critical care routinely involves continuous assessment of every individual patient's progress, the likelihood of an outcome that is acceptable to the patient, and the adjustment of treatment plans in light of these factors.
- On admission to intensive care, the patient's expectations and the goals of treatment should be reviewed.
- All patients must have at least daily review by an intensive care consultant to assess whether the goals of treatment are being met and whether the outcomes expected at admission remain realistic. If an intensive care consultant is not available for direct review, the assessment can be delegated by them to a clinician with knowledge of intensive care interventions and outcomes. Responsibility for any decisions taken in light of these reviews remains with the intensive care consultant.

- Regular communication updates with the patient's representative by informed members of the critical care team are recommended. Consideration should be given to the use of approved videoconferencing when visiting for relatives may not be possible.
- When treatment is limited or withdrawn, there must be clear and complete documentation of the rationale for any decisions, and documentation of discussions with the patient or their representative (as determined by each nation's legal framework) and any other clinical staff involved.
- Decisions about withdrawal or limitation of treatment for patients being treated by intensive care services should be made by the **intensive care consultant responsible for the patient.** In exceptional circumstances, responsibility for such decisions can be delegated by them to a senior clinician with knowledge of intensive care interventions and outcomes. Responsibility for these decisions remains with the intensive care consultant.
- When treatment is limited or withdrawn, the priority will become to deliver the best possible end-of-life care to the patient. The benefit of involving a palliative care team should be considered, especially if the patient is managed outside the intensive care unit.
- Review of TEPs should occur before ward discharge of survivors of critical care.

5 Management of respiratory failure

Oxygen therapy

- Avoid hyperoxaemia in patients receiving supplemental oxygen.
- Generally, aim for SpO_2 92-96%, although the target will be lower in some patient groups, e.g. those with chronic obstructive pulmonary disease (COPD).
- An SpO_2 target of 90-93% is acceptable in patients with visible continuous pulse oximetry in an appropriately monitored care environment with trained staff to monitor for clinical deterioration.

Oxygen supply

- There is likely to be substantially increased oxygen demand in hospitals treating large numbers of COVID-19 patients, as a result of increased use of face mask oxygen in general and acute beds, non-invasive devices such as high flow nasal O2 therapy and CPAP, and continued use of ventilators in both critical care and operating theatres. Several critical incidents related to oxygen demand occurred in the first COVID-19 wave.
- High demand, particularly in cohorted areas outside theatres or critical care, may lead to pressure drops in the oxygen supply system that may affect oxygen flow to individual patients or areas.
- There are a number of other risks associated with unusually high oxygen usage including icing of vacuum insulated evaporators (VIEs - the liquid oxygen storage tanks outside hospitals). VIE icing can also lead to oxygen supply drops.

- Preparation for treatment of increased numbers of COVID-19 patients, particularly in surge centres, must involve local oxygen engineering teams, with attention paid to planned locations of treatment with high-flow oxygen devices, and potential systems limitations.
- Clinicians can support safe oxygen use by reducing waste. For example: ensure oxygen flowmeters and high-flow devices are switched off when not attached to patients; avoid large cuff or mask leaks in patients using ICU ventilators as the automatic compensation to maintain PEEP can consume up to 50-60 litres/min O_2; exert caution when switching to high-flow nasal devices for comfort breaks from low flow CPAP systems.
- If oxygen alarms sound, this must be taken seriously, oxygen engineering teams called and an immediate review of all oxygen usage undertaken to reduce unnecessary use.
- Other information about safe oxygen use can be found in this CAS-Alert. https://www.cas.mhra.gov.uk/ViewandAcknowledgment/ViewAlert.aspx?AlertID=103020

For both high-flow nasal oxygen (HFNO) and CPAP/NIV

- Use only MHRA approved devices.
- Continuous monitoring of SpO_2, in a care environment with trained staff to monitor for clinical deterioration is essential. This applies equally to both critical care and non-critical care areas.
- Use should be considered an aerosol generating procedure (AGP), and PPE should be consistent with relevant PHE guidance.

CPAP and NIV

- Please see the specialty guide for more details here.
- In selected patients who do not require immediate invasive mechanical ventilation, CPAP devices (via a non-venting face mask or helmet) may be trialled to assess whether invasive mechanical ventilation can be avoided under the following circumstances:
  - Failure to respond to a CPAP trial (deterioration in gas exchange; high work of breathing) is an indication for early intubation and invasive mechanical ventilation in patients considered appropriate for escalation.
  - Low-flow CPAP devices using entrained oxygen may be suitable for patients with a lower oxygen requirement (FiO_2 <0.4).
  - Some milder severity patients may improve symptomatically after short periods (1-4 hours) of CPAP with corresponding reductions in FiO_2, respiratory rate and work of breathing to maintain adequate SpO_2 values.
- Patients who do not respond clinically to a CPAP trial (deterioration in gas exchange, high work of breathing), and/or do not tolerate CPAP, should undergo early intubation and invasive mechanical ventilation according to the appropriateness of escalation.
- Patients may look comfortable on CPAP in the early phase of illness when lung compliance is normal. Elevated or increasing spontaneous minute ventilation may be an indicator of clinical deterioration or disease progression.
- For some patients, CPAP or NIV will form the appropriate ceiling of treatment. Identify these

patients early to prevent inappropriate escalation to invasive support.

- NIV (BiPAP) is not generally indicated in hypoxaemic respiratory failure but may be considered in certain patient groups with Type 2 respiratory failure, e.g. COPD.
- An appropriate antimicrobial filter should be located on the expiratory limb of any NIV or CPAP device.
- Due to a risk of environmental viral contamination, when possible deliver mask ventilation in an isolated environment (negative or neutral pressure room - check the air exchanges in positive pressure rooms - or cohort in restricted access areas).
- Awake prone positioning may improve V/Q mismatch, oxygenation and work of breathing and may be combined with HFNO, CPAP or NIV.
- The type and location of respiratory support after extubation, e.g. CPAP, high or lower flow O_2, should be informed by clinical assessment, repeat testing of SARS-CoV-2 status (when available), and balancing the risks of cross-infection with the benefits of different approaches.
- Consideration should be given to cohorting extubated patients according to SARS-CoV-2 status both in ICUs and step-down units.

HFNO

- HFNO or similar high-flow devices are of uncertain utility but are increasingly being used in other countries, e.g. the USA.
- RECOVERY-RS is a large randomised clinical trial comparing HFNO with CPAP and "standard care" (oxygen mask or nasal specs). Enrolment into this trial is recommended in patients for whom HFNO is being considered.
- Similar clinical considerations apply to HFNO as to CPAP and NIV (see above)

Intubation

- Follow intubation guidance from: https://icmanaesthesiacovid-19.org
- Intubation in likely COVID-19 patients should be performed by a skilled operator wearing appropriate PPE for an aerosol-generating procedure. See PHE IPC guidance here
- The use of Mobile Emergency Rapid Intubating Teams with appropriate portable equipment, PPE and protocols are recommended, but will be dependent on available local staffing resources.
- Clamping of endotracheal tubes, e.g. during exchange of breathing systems, is useful to minimise the risk of environmental viral contamination. Take care not to damage the tube or pilot tube. Clamping should be performed away from the plastic of the 15mm circuit connector. There may be a risk of the tracheal tube subsequently kinking at the point at which the tube has been repeatedly clamped.
- For tracheal tubes with subglottic suction ports, clamping at 90° to the plane of the sub-glottic channel may reduce the risk of sub-glottic channel fracture
- Any adverse incidents should be reported through local and national reporting systems to spread learning from events across the healthcare system and to help prevent future incidents.

Mechanical ventilation

- Ensure use of an antimicrobial filter within the circuit or placed on the expiratory limb or ventilator exhaust. **Note that filters can represent an airflow obstruction risk if saturated, and frequent assessment and replacement is advised.**
- Heated humidifiers can cause rapid saturation of inline filters and the combination should be used with caution. If possible, when using a heated humidifier circuit, attach the antimicrobial filter to the ventilator exhaust.
- Use of dry circuits with HME filters can cause secretion build-up and obstruction of tracheal tubes. Regular nebulised saline (normal or hypertonic) ± mucolytics (inline with respiratory circuit) may be useful BUT may contribute to circuit obstruction through saturation of filters and salt crystal build-up within ventilator expiratory blocks.
- **Airflow obstruction due to saturation of antimicrobial filters, particularly when used with heated humidifiers or nebulisation, may be indicated by sudden or progressive deterioration in:**
  - **(i) minute ventilation**
  - **(ii) capnography**
  - **(iii) airway pressures**
- Use inline suction systems where possible.
- Avoid inadvertent ventilator circuit disconnections by ensuring all connections are 'tight'.
- Manual ventilation, e.g. 'hand-bagging' with a bag-valve-mask or anaesthetic circuit plus face mask, should generally be avoided due to concerns about aerosol generation and infection risk.
- Clamp the tracheal tube and set the ventilator to pause/standby during any planned circuit disconnection, e.g. switching between ventilators, during proning/deproning manoeuvres, replacing the antimicrobial filter, or inserting a bronchoscope into the catheter mount.
- Anaesthetic machines are not recommended /for ventilation of critical care COVID-19 patients unless there is a specific indication.
- A number of new, perhaps unfamiliar, ventilators may be present. Use of available educational resources, training and a period of familiarisation should take place.

Ventilatory management

- COVID-19 respiratory failure requiring ventilation may present on a spectrum that extends from an early phase of pulmonary vasculopathy/thrombosis, focal ground glass inflammation, and possible loss of hypoxic pulmonary vasoconstriction to a later phase of atelectasis, increase in non-aerated pulmonary units and deterioration in pulmonary mechanics with low compliance. Ventilatory management will depend on the phenotype (determined by imaging, pulmonary mechanics and response to ventilation manoeuvres)
- Standard protective lung ventilation guidelines used for ARDS should be deployed: aim for tidal volumes of 6 mL/kg and driving pressure <15 cmH_2O (driving pressure = plateau pressure – PEEP).
- When compliance is normal, PEEP ≤10 cmH_2O is often sufficient, and a high PEEP strategy may be

harmful. As compliance deteriorates, higher PEEP levels may be appropriate.

- Neuromuscular blockade to avoid high transpulmonary pressures and further lung injury should be considered if there is ventilator dysynchrony or a high spontaneous minute ventilation.
- Recruitment manoeuvres have not been shown to improve outcome but may improve gas exchange in low compliance lungs.
- Inhaled pulmonary vasodilators, e.g. nitric oxide, nebulised iloprost or epoprostenol, may improve V/Q mismatching although use will likely be less effective with increased deadspace due to pulmonary thrombi. No data are available to evidence outcome improvement.
- Improvements in oxygenation can often be achieved with prone positioning (see below).
- Conservative fluid management strategies are beneficial but be careful to avoid **hypovolaemia**.
- If other strategies fail, discuss with ECMO centre.

Prone positioning

- No studies are available to demonstrate outcome benefit from prone positioning in COVID-19 patients. An improvement in gas exchange if often seen with prone positioning in awake patients (either on an oxygen face mask alone or receiving HFNO/CPAP/NIV), or ventilated patients in both early and later phases of the disease. However, the benefit may wear off after several hours for some patients.
- Proning should take place in an appropriately monitored care environment with trained staff. Turn head regularly, e.g. 3 hourly, and be careful about potential injury to eyes, pressure areas, shoulders and obstruction/displacement of tracheal tube/tracheostomy.
- Significant haemodynamic and/or respiratory decompensation can occur during the act of proning. While patients generally recover after a short period, clinicians should be prepared for these complications and treat accordingly. If necessary, the procedure may need to be abandoned.
- If proning is used, it is recommended for 16-18 hours per day (longer may be acceptable) – multiple episodes over the course of up to a week may be beneficial.
- 'Proning Teams' will improve efficiency when substantial numbers of patients are being turned. The Proning Team may comprise staff from non-ICU backgrounds under supervision of a suitably skilled member of ICU staff. However, use of Proning Teams will depend on local staffing resources.
- The optimal timing for starting prone positioning and optimal duration of a proning course remain uncertain. A pragmatic approach should be adopted, depending on local resources. It is reasonable to continue daily in responders until there has been a significant and stabilised improvement in P:F ratio, whereas it can be discontinued after 1-2 days in non-responders. Patients may experience symptomatic benefit without necessarily showing improvements in gas exchange.

Tracheostomy

- Advice for care of patients currently with a tracheostomy is available.
- Airway oedema is common (see comments below under extubation); a large UK audit of 1605 patients showed 5% required upsizing of tubes.
- Decision making in relation to new tracheostomies needs to balance the risk of infection (aerosol spread of SARS-CoV-2) with the best management for the patient within the available resources:
  - https://associationofanaesthetists-publications.onlinelibrary.wiley.com/doi/10.1111/anae.15120
  - https://icmanaesthesiacovid-19.org/considerations-for-tracheostomy-in-the-covid-19-outbreak
- Tracheostomy may:
  - facilitate weaning from mechanical ventilation and patient comfort
  - allow reduced use of sedation and, consequently, pressor medication
  - enable safe management with lower staffing and equipment levels.
- Staff must have the training and experience to care for tracheostomised patients.
- Tracheostomised patients who remain SARS-CoV-2 +ve carry an ongoing risk of viral aerosolisation.
- No studies have determined the optimal timing or optimal procedure (percutaneous or surgical). Observational data indicate that tracheostomy is generally performed later than usual but there is no clear indication of short-term or long-term harm as a consequence. Tracheostomy should perhaps be avoided in patients with a high oxygen and/or ventilator support requirement and/or a high/increasing inflammatory biomarker profile.

NIV and weaning

- NIV or CPAP (including in patients with tracheostomies) may be useful to aid weaning from ventilator support.
- NIV machines may be used in place of ICU ventilators when there are equipment shortages.

Extubation

- Need for reintubation is associated with airway swelling, tenacious secretions, weakness and delirium.
- Early extubation (<7 days) is more likely to be associated with failure.
- To minimise reintubation rates, careful and comprehensive clinical assessment should be undertaken before planned extubation.

- Extubation should be delayed until there is a consistently improving trajectory in the following:
  - breathing pattern, including markers of respiratory and cough strength
  - ability to self-clear secretions
  - chest radiology
  - markers of inflammation and thrombosis
  - oxygenation and mean airway pressure and PEEP.
- Use of a spontaneous breathing trial with monitoring of RSBI, NIF and P0.1 may be useful in assessing adequacy of ventilation and likelihood of successful extubation, albeit that these tests will not detect airway swelling, which is common.
- 'Cuff leak' tests may be useful for assessing airway swelling. Be aware that there may be an associated aerosol generation risk.
- Consider upper airway visualisation before extubation to assess for swelling.
- Dexamethasone or methylprednisolone may be used to reduce airway oedema.

Extracorporeal membrane oxygenation (ECMO)

- Follow published pandemic guidance and thresholds for referral to the ECMO network here
- ECMO referral data will be communicated via a single platform here
- ECMO network regional centres can be contacted for advice and guidance.

Aerosol-generating procedures (AGPs)

- AGPs such as intubation and extubation, facemask ventilation, HFNO, CPAP and NIV, circuit disconnection, bronchoscopy, tracheostomy formation and some physiotherapy procedures will increase the risk of environmental viral contamination. Please see the PHE website for the full list and guidance on appropriate PPE
- Nebulisers are not considered an AGP

Corticosteroids

Patients who required supplemental oxygen should have received a 10-day course of dexamethasone 6 mg od, I.V. or p.o. After completion of dexamethasone therapy, a proportion of patients with persistent lung inflammation may potentially benefit from subsequent, and possibly higher-dose, corticosteroid treatment, although no outcome data are available. Use should be guided by MDT decision-making on an individual patient basis, taking into account radiological imaging, deteriorating pulmonary mechanics and biochemical markers of persistent inflammation. ECMO network centres can be contacted for advice and guidance.

Secondary or co-infection

- Viral co-infection is possible. Seek evidence of this even if SARS-CoV-2 is detected, and vice versa.
- Secondary or co-infection with bacterial and/or fungal infection may be seen, generally later in ICU stay.
- Standard markers of Ventilator Acquired Pneumonia (VAP) are less helpful in COVID-19, as fever and rising CRP are often seen as part of the SARS-CoV-2 inflammatory process. The latter is suggested by concurrent rises in ferritin, LDH, BNP and troponin.
- Perform regular microbiological surveillance, including fungal biomarkers (ß-D-glucan and Galactomannan) and molecular diagnostics, if available. Patients who have been given steroid therapy may be more prone to reactivation of pathogens such as CMV, HSV and VZV.
- PCT may be useful in helping to guide decision-making around antimicrobials.

6 Management of non-respiratory organ failure

Cardiovascular

- It is not clear whether hypertension alone is a risk factor for severe COVID-19 disease.
- Antecedent cardiovascular disease, for example cardiomyopathy or coronary vascular disease (found in >30%), may be associated with increased mortality.
- Raised cardiac troponin (TnT) may be associated with increased mortality.
- Raised NT-proBNP level may occur and is strongly associated with poorer outcome.
- Histological evidence of myocarditis is currently weak and raised TnT alone is not sufficient for this diagnosis, which is made by exclusion. When it occurs, it appears to do so 10-15 days after symptoms first appeared.
- Right sided cardiac dysfunction is associated with increased mortality risk and appears more common than left sided heart failure.
- Acute pericarditis can occur but cardiac tamponade is rare.
- Remember: acute coronary syndromes can still occur. Diagnosis can be difficult given that raised TnT is common. Echocardiography (regional wall motion abnormality) and ECG may help. Seek expert cardiology advice.
- Arrhythmias are common, e.g. AF and bradycardia, and should be managed in a normal fashion.
- In case of cardiac arrest, chest compressions should be commenced immediately. Survival from in-hospital cardiac arrest in COVID-19 patients is 20% in those under 45 years of age, but 3% in those aged 80 or more. Whilst PHE do not consider chest compressions to be an AGP, the current position of the Resuscitation Council UK is that chest compressions are an AGP and that PPE should be worn.

- Definitive airway management may generate aerosols and should not be performed until all staff are wearing appropriate PPE. The availability of 'grab bags' and resuscitation team rehearsal can help with the speed of response. Airway interventions must be carried out by experienced staff.
- Hypotension or circulatory shock should be managed according to usual practice. A fluid strategy in favour of clinical euvolaemia is recommended.

Renal

- AKI requiring renal replacement therapy (RRT) is reported in >25% of COVID-19 patients admitted to critical care, with a median duration of use being 8 days.
- Management should follow current consensus recommendations for AKI in critically ill patients.
- Whilst a degree of relative water depletion might be sought or tolerated in order to improve pulmonary gas exchange in some, care should be taken to ensure that renal perfusion is maintained.
- Renal perfusion may be compromised by high airway pressures and high PEEP.
- Due to the prothrombotic state of most ICU COVID-19 patients, anticoagulation to prevent filter clotting should be augmented. Several strategies are available, including switch to intravenous unfractionated heparin infusion, enhanced sub-cutaneous low-molecular weight or combination of regional citrate with heparin (iv infusion or low molecular weight heparin).
- Continuous RRT (CRRT) is the preferred modality. If demand for CRRT machines exceeds capacity, consider alternative modalities including prolonged intermittent RRT using CRRT machines, acute peritoneal dialysis (when local expertise and issues such as proning allow) or intermittent haemodialysis (if the patient is stable enough in terms of cardiovascular and respiratory stability), and/or mutual aid.
- Guidance on RRT can be found here

Thromboprophylaxis and treatment of thromboembolus

- Prothrombotic phenotype is common (high fibrinogen and D-dimer). At least 30% of ICU patients may develop a thromboembolic event (VTE in 25% of all patients, arterial thrombotic events in 3.7% (95% CI: 0 - 8.2%) even when receiving standard thromboprophylaxis.
- Pay great attention to thromboprophylaxis including non-pharmacological methods (intermittent pneumatic compression stockings, TEDS).
- In the absence of trial data, international guidelines relating to thromboprophylaxis vary: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7492793/.
- We recommend that low-molecular weight heparin be administered at twice the normal prophylactic dose. Thomboprophylaxis administration should be guided by careful consideration of the competing risks of thrombosis and bleeding.
- Have a high index of suspicion for the presence of deep venous or pulmonary vascular thromboembolism and investigate urgently where clinical suspicion is raised, e.g. if a sudden deterioration in gas exchange occurs, or if D-dimers remain elevated or show a stepwise rise.
- For treatment of thromboembolism, there are advantages to the use of anti-Xa assay (when available) rather than aPTT to monitor unfractionated heparin dosing, particularly if renal impairment is present.

Feeding

- Perhaps 4% of patients present to hospital with only GI symptoms, but these are rarely an issue on ICU.
- Failure of enteral nutrition is likely due more to the use of drugs (such as opioids) and this factor - together with possible intra-abdominal pathology - should be considered.

Skin

- Skin involvement is commonplace and manifests most commonly as a maculopapular rash or urticaria.
- Chilblains ('Covid Toe') and vesicular lesions are also seen, with livedo reticularis seen less frequently.
- Spreading fungal infections should be excluded when this diagnosis appears possible.

Liver

- About half of COVID-19 patients may get raised ALT/AST/GGT/bilirubin levels – no specific intervention is advocated.

Neurological

- Seizures may occur in about 0.5% of hospitalised patients.
- Stroke (perhaps 1%, due largely to large vessel thrombotic/embolic occlusion) and reduced consciousness (<15%) tend to occur late in the disease. Critical illness *per se* can cause an axonal motor neuropathy.
- Delirium or changes in executive function are common. In part, this may relate directly to SARS-CoV-2 infection but may relate to loss of circadian rhythm and use of analgosedation.
- Short acting sedatives and analgesics should be used as is standard practice while supply is assured.
- Non-pharmacological interventions should be used: ear plugs at night, eye pads to limit light exposure at night, orientation, sleep hygiene (including normalisation of day/night cycle), objective pain assessments and mobilisation

Less commonly occurring are:

- (Meningo)encephalitis
- Motor neuropathy of the Guillain-Barré type
- Transverse myelitis

Musculoskeletal

- Muscle wasting is common.
- Skeletal CK may be elevated. Origin should be confirmed (compare with cardiac troponin levels anddo CK isoforms when indicated and readily available).
- ICU Acquired Weakness (due to neuromuscular impact) affects all ventilated ICU COVID-19 patients to some degree, impacting on weaning and rehabilitation.
- Once off sedation, perform daily Chelsea Critical Care Physical Assessment (CPAX) Score.
- Use Medical Research Council Sum Score (MRC-SS: p3) to diagnose ICU-AW.
- A framework for assessing the early rehabilitation needs of post-COVID-19 ICU patients is now available.
- Mobilise according to local practice.

Hyperglycaemia

- Insulin resistance is common in COVID-19. Glucose-lowering strategies may need to be intensified, including the administration of long-acting insulin. In the recovery phase, carefully monitor and respond to changing insulin requirements. Guidelines for managing hyperglycaemia in COVID-19 patients can be found here: https://abcd.care/sites/abcd.care/files/resources/COvID_Hyper_v4.2.pdf

7 Further guidance

Nutrition guidelines

- British Association for Parenteral And Enteral Nutrition (BAPEN)
  Route of Nutrition Support in Patients Requiring NIV & CPAP During the COVID-19 Response
- British Dietetic Association (BDA)
  Critical Care Specialist Group COVID-19 Best Practice Guidance: Enteral Feeding in Prone Position

After-care needs

- NHS England
  After-care needs of inpatients recovering from COVID-19