Bedside Guide Ventilator Emergency Care for COVID-19 patients

Guidance from the Chartered Institute of Ergonomics and Human Factors

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Foreward

The Chartered Institute of Ergonomics & Human Factors (CIEHF) received its Royal Charter in 2014 to recognise the uniqueness and value of the scientific discipline and the pre-eminent role of the Institute in representing both the discipline and the profession in the UK. This includes the protected status of "Chartered Ergonomist and Human Factors Specialist" with the post-nominal C.ErgHF awarded to practising Registered Members/Fellows who are among a group of elite professionals working at a world-class level.

This bedside guide is intended for the use of clinical staff with basic anaesthetic training who have been assigned to care for ventilated patients. The tasks described should NOT be attempted by those with a lower level of training. This does not override the responsibility of the healthcare provider to use professional judgement and make decisions appropriate to the circumstances of each patient in consultation with the patient and/or guardian.

Dr Noorzaman Rashid

Chief Executive

Chartered Institute of Ergonomics and Human Factors

The CIEHF has assembled expert panels consisting of clinicians and healthcare managers, scientists and engineers, academics and researchers, quality improvement, human factors professionals and ergonomists to support the development and review of guidance on a wide range of procedures.

Contact: Covid19@ergonomics.org

Caveat: This Human Factors/Ergonomics (HFE) advice is offered by Chartered Ergonomists & Human Factors Specialists (C.ErgHF) on a rapid response basis and does not reflect a full HFE analysis. The advice was offered within the Chartered Institute of Ergonomics and Human Factors (CIEHF) scope of practice for a Chartered Registered Member/Fellow
https://www.ergonomics.org.uk/Public/membership/registered_member.aspx

Problem	Indicated By	Action Card
AIR LEAK	**Sound of gurgling or escaping air** during ventilation (patient) **Air Leak alarm** (ventilator)	1
HYPOXIA	**Desaturation/low arterial oxygen level** (SpO_2 <88%)	2
HYPOTENSION	**Low Blood Pressure** (Mean BP <60 or Systolic <90 via arterial line or Cuff)	3
HYPERTENSION	**High Blood Pressure** (Mean BP >100 or Systolic >140 via arterial line or Cuff)	4
INCREASED AIRWAY PRESSURE	**High Airway Pressure (>30cm H_20)** alarm	5
APNOEA	**Apnoea or Low Respiratory Rate alarm** (RR<6) or visual observation	6
HIGH RESPIRATORY RATE OR MINUTE VOLUME	**High Minute Volume** alarm, or **High Respiratory Rate** alarm, or **High Tidal Volumes** alarm	7
LOW MINUTE VOLUME	**Low Minute Volume** alarm (ventilator)	8
VENTILATOR FAILURE	**Catastrophic Failure (power or ventilator)**	9
UNPLANNED EXTUBATION	**ET tube not in airway, large air leak, Apnoea or Low Minute volume alarm**	10

How to use this document

The action cards are designed to be printed, laminated and kept at the bedside.
Clinical information is all on one side; the reverse is **blank** with a CIEHF infographic about procedure design.

Competence: Users of this bedside guide must be trained and work within their clinical competence for COVID 19.b.

Personal Protective Equipment (PPE): Follow local PPE guidance or use PPE for aerosol producing procedures.

Purpose:

- To stabilise the patient whilst getting help
- To support previous training for staff with limited experience of ventilated patients
- Can be read as a daily reminder for mental rehearsal, or read out by a second person
- Assumes that the setting is an acute hospital (not community)
- Assumes that other tasks may have to be carried out - these may not be mentioned on the bedside guide.

Remember:

- Personnel may need to don PPE before being able to assist. This will increase the response time
- Call for emergency assistance if you are concerned; a compromised airway is an emergency.

ACTION CARD

1

COVID-19

AIR LEAK

Sound of gurgling from mouth or escaping air
Air leak alarm

1) Assess ventilation

- Check CO_2 trace present, chest wall rise, measured tidal volume on ventilator, SpO_2.
- If patient is not being ventilated, **call for help and follow accidental extubation (Action Card 10).**

2) Call for help

Use alert phrase 'Emergency in (patient location); airway problem'.

3) Conduct clinical reasoning and fault tracing

A. Airway:

- **Confirm airway patent with end tidal CO_2 trace recording & chest wall rising**
- Ventilator: **Check SpO_2 and increase FiO_2 if needed**
- Breathing tube:
  - Grip, keeping breathing tube still to prevent displacement
  - Check the recorded length markings at incisors: should usually be 20-24cm
  - Check that the pilot balloon is inflated. **If not, re-inflate**
  - **If breathing tube has slipped, hold breathing tube until help arrives**
  - Systematically check for leak in the circuit. include valves, filters & connections.

B. Breathing:

- If patient is coughing or moving, **consider bolus of sedation** (e.g. 1-2ml of propofol and /or opiate).

Reassess airway and breathing. If further concern, call expert support

Possible Causes

- Cuff is inflated and breathing tube is displaced. Outward with cuff herniating above the larynx.
- Cuff is deflated and breathing tube is in the correct place.
- Cuff is inflated and breathing tube is in the correct place but **airway pressures are high (Action Card 5).**
- Ventilator circuit disconnected or leak.

Pilot Tube

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- Identify hazards
- Capture how your work is really done
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Test 02

- Ask people who will use it to test it
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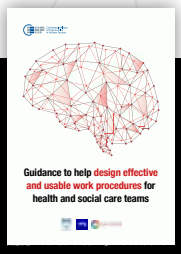
For more visit the *10 key steps to designing work better* process journey **https://bit.ly/DesignofWorkProcedures**

Read the full guidance on human-centred design of work procedures



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ACTION CARD

2

COVID-19

HYPOXIA

Desaturation/low arterial oxygen level (SpO_2 <88%)

1) Call for help

Use alert phrase 'Emergency in (patient location); airway problem'

2) Conduct clinical reasoning and fault tracing

- Check pulse oximeter probe is positioned securely onto finger.
- Check finger perfusion not affected by limb compression.
- Consider list of possible causes listed below.

A: Airway
- **Confirm airway is patent** with end tidal CO_2 trace being recorded and chest wall rising
- Ventilator: Check SpO_2; **check oximeter probe position and trace.** Increase FiO_2 to 100% if needed
- Breathing tube: **Check the recorded length.** Check the markings near the teeth match the recorded length (recorded length is usually 20-24cm). If leak, **see Action Card 1.**

B: Breathing
- Assess chest for symmetrical chest rise, respiratory rate, measured tidal volumes and pressures on ventilator, end tidal CO_2 and SpO_2 values
- Ventilator: If low tidal/minute volumes **see Action Card 8**; If increased airway pressures, **see Action Card 5**
- Breathing system: Visually inspect entire breathing system including valves, filters and connections.

C: Circulation
- Assess pulse, heart rate, rhythm, and blood pressure (compare non-invasive with invasive blood pressure)
- Obtain an arterial blood gas and consider chest x-ray
- If desaturating, disconnect from ventilator and hand ventilate via self-inflating bag and 100% O_2.

Reassess airway and breathing. If further concern, call Expert Support

Possible Causes

Airway:
- **Air leak (Action Card 1)**
- Breathing tube too far in (bronchial intubation)
- Breathing tube blocked (e.g. by secretions)
- Breathing tube dislodged or circuit disconnection.

Breathing:
- Bronchospasm
- Pulmonary oedema
- Aspiration/pneumonia
- Breathing Cont.
- Pulmonary embolus
- Lobar collapse from mucous plug
- Pneumothorax
- Patient ventilator asynchrony ('fighting the ventilator')
- Incorrect ventilator settings.

Circulation:
- Shock/Low cardiac output.

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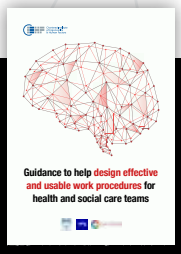

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ACTION CARD

3

COVID-19

HYPOTENSION

Low Blood Pressure (Mean BP <60 or Systolic <90 via arterial line or cuff)

1) Call for help

Use alert phrase 'Emergency in (patient location); airway problem'

2) Conduct clinical reasoning and fault tracing

A. Airway:
- Check SpO_2 and increase FiO_2 to 100% if needed
- Confirm patient airway from end tidal CO_2 trace and check position of breathing tube using markings at teeth (normally 20-24cm).

B. Breathing:
- Assess the chest for symmetrical chest rise, respiratory rate, measured tidal volumes and pressures on ventilator, end tidal CO_2 and SpO_2 values.

C. Circulation:
- Assess **pulse, heart rate, rhythm, and adequacy of blood pressure waveform** (compare non-invasive with invasive blood pressure if waveform damped)
- Ensure that the arterial line pressure transducer is level with the heart. Flush the arterial line by pulling the blue tab on the transducer
- If vasoactive drug infusion ongoing, **check that drug is being delivered**
- Assess and treat possible causes following normal medical algorithms
- Consider **fluid bolus** (250ml crystalloid)
- Consider **changing patient position** (move head down or elevate legs) while keeping hold of breathing tube to avoid displacement
- **Locate vasopressor drugs** for use by trained clinicians.

Reassess airway and breathing. If further concern, call Expert Support

Possible Causes

Airway:
- Breathing tube in too far and causing bradycardia from vagal stimulus.

Breathing:
- High intrathoracic pressure
- (e.g. Pneumothorax, gas trapping)
- Profound hypoxia
- Pulmonary embolus

- Vasopressor infusion inadvertently stopped.

Circulation:
- Arterial line in wrong position or blocked
- Vagal stimulus from other causes e.g. during suctioning
- Hypovolaemia (sepsis, haemorrhage)
- Reduced venous return secondary to positive pressure ventilation
- Cardiac ischaemia (check ECG)
- Cardiac arrhythmia (check electrolytes).
- Drugs causing vasodilation (e.g. propofol).

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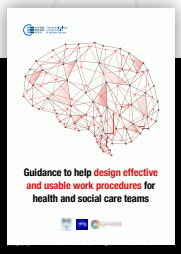

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ACTION CARD

4

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HYPERTENSION

High Blood Pressure (Mean BP >100 or Systolic >140 via arterial line or cuff)

1) Call for help

Use alert phrase 'Emergency in (patient location); airway problem'

2) Conduct clinical reasoning and fault tracing

Confirm hypertension by:
- Re-check blood pressure (compare non-invasive blood pressure with invasive blood pressure) Ensure non-invasive blood pressure cuff is of the appropriate size
- Ensure that arterial line pressure transducer is at the level of the patient heart
- Flush the arterial line by pulling the blue rubber tab on the transducer.

A. Airway:
- Confirm airway is patent by checking for functioning end tidal CO_2 trace, & check position of breathing tube.

B. Breathing:
- Assess chest for symmetrical chest rise, respiratory rate, measured tidal volumes and pressures on ventilator, end tidal CO_2 and SpO_2 values.

C. Circulation:
- Assess pulse, heart rate, rhythm, and blood pressure.

Disability
- If sedative drug infusion ongoing, check that drug is being delivered.
- Administer a bolus of sedation (e.g. 1-2 ml of propofol and/or opiate).

Reassess airway and breathing. If further concern, call Expert Support

Possible Causes

- Pain.
- Agitation or inadequate sedation (including loss of IV access/infusion line blocked or clamped).
- Patient ventilator asynchrony.
- Elevated arterial CO_2 (check ABG).
- Drug error (e.g. inadvertent bolus of vasopressor).
- Omission of usual antihypertensives.
- Distended bladder/blocked catheter.

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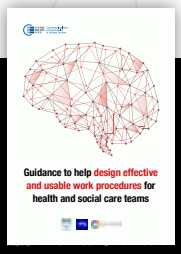

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ACTION CARD

5

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INCREASED AIRWAY PRESSURE

(>30 H_2O) alarm

1) Call for help

Use alert phrase 'Emergency in (patient location); airway problem'

2) Conduct clinical reasoning and fault tracing

A. Airway:
- Confirm airway patent with end tidal CO_2 trace and chest wall rise
- Check SpO_2 and increase FiO_2 to 100% if needed
- Check breathing tube length marks at incisors and compare to expected (recorded) length (usually 20-24cm).

B. Breathing:
- Breathing tube:
  - If patient biting on tube, or coughing, consider bolus of sedation (1-2 ml of propofol and/or opiate)
  - If tube in correct place, perform urgent closed in-line suction
  - Check for kinks (including inside mouth) and foreign objects (tape)
  - If HME filter in place ensure it is not water-logged/occluded, replace if any doubt
  - If active/wet humidifier is being used check circuit not full of water.
- Assess chest for symmetrical chest rise, respiratory rate, measured tidal volumes and pressures on ventilator, end tidal CO_2 and SpO_2 values.

C. Circulation:

Check pulse, heart rate, rhythm, and blood pressure.

Reassess airway and breathing. If further concern, call Expert Support

Possible Causes

Airway problems:
- Blockage in tube by secretions, plastic, foreign body
- Blocked/waterlogged HME filter
- Patient biting on tube
- Breathing tube in too far (endobronchial)
- Excess water in ventilator circuit from active/wet humidifier.

Breathing problems:
- Patient coughing/resisting against the ventilator due to insufficient sedation or muscle relaxation
- Pneumothorax
- Bronchospasm
- Aspiration
- Pulmonary oedema
- Ventilator tidal volume set too high.

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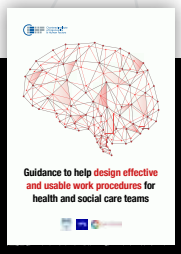

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ACTION CARD

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COVID-19

APNOEA

Apnoea or low respiratory rate alarm (RR <6)

1) Call for help

Use alert phrase 'Emergency in (patient location); airway problem'

2) Conduct clinical reasoning and fault tracing

A. Airway:
- Confirm lack of end tidal CO_2 trace and chest wall rise
- Ventilator: Check SpO_2 and increase FiO_2 to 100% if needed
- Visually confirm breathing tube is in correct position and check the entire circuit from patient to ventilator to ensure no disconnections/blockages. If any concern and not able to correct, disconnect ventilator and commence manual ventilation with self-inflating bag and 15L of O_2
- If disconnection, reconnect
- If breathing tube displaced call for support and follow unplanned extubation Action Card 10
- If an HME filter in place ensure it is not waterlogged/occluded, replace if any doubt.

If no end tidal CO_2 trace but normal chest wall rise consider fault with capnography.

B. Breathing:
- Ensure patient is on a controlled mode of ventilation
- Assess chest for symmetrical chest rise, respiratory rate, measured tidal volumes and pressures on ventilator, end tidal CO_2 and SpO_2 values
- If apnoea persists, disconnect ventilator and commence manual ventilation with self-inflating bag attached to breathing tube with oxygen flow at 15 L/min.

C. Circulation:
- Assess pulse, heart rate, rhythm, and blood pressure (compare non-invasive with invasive blood pressure).

Reassess airway and breathing. If further concern, call Expert Support

Possible Causes

Airway:
- Tube disconnected from circuit
- Disconnection within ventilator circuit
- Breathing tube displaced from airway
- Capnography fault (disconnected, blocked sampling line).

Breathing (if on a spontaneous mode of support):
- Over sedation or excessive opioids (during spontaneous mode of support)
- Patient fatigue
- Intracerebral event.

Circulation:
- Cardiac arrest.

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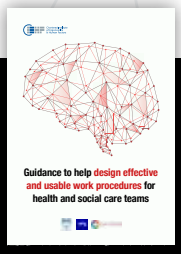

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ACTION CARD

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HIGH RESPIRATORY RATE or MINUTE VOLUME

1) Call for help

Use alert phrase 'Emergency in (patient location); airway problem'

2) Conduct clinical reasoning and fault tracing

A. Airway:
- Confirm airway patent with end tidal CO_2 trace and chest wall rise
- Check position of breathing tube by comparing marking at teeth with expected recorded length (usually 20-24 cm)
- Check SpO_2 and increase FiO_2 to 100% if needed
- Check if tube or filter blocked by secretions: perform closed in line suction.

B. Breathing:
- Assess chest for symmetrical chest rise, respiratory rate, measured tidal volumes and pressures on ventilator, end tidal CO_2 and SpO_2 values.

C. Circulation:
- Assess heart rate, rhythm, and blood pressure.

Reassess
- **IF ABC satisfactory** and it is safe to do so, consider bolus of sedation (1-2ml of propofol and/or opiate). Ensure that the sedation is being delivered (cannula intact and lines connected and unclamped).
- Consider causes of high expiratory minute volume (below), check arterial blood gases and whether a chest x-ray or other investigation may be appropriate.

Reassess airway and breathing. If further concern, call Expert Support

Possible Causes

- Pain.
- Agitation e.g. during sedation hold or inadequate sedation.
- Anxiety especially with delirium including inability to communicate or restless.
- Incorrect ventilator settings (e.g. low tidal volume or low pressure support).
- Fever.
- Hypercatabolic states e.g. sepsis, seizures.
- New lung pathology e.g. pulmonary embolus, pneumonia, aspiration, pulmonary oedema **(see: Action Card 2).**

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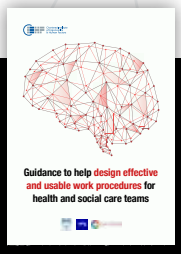

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ACTION CARD

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LOW MINUTE VOLUME

1) Call for help

Use alert phrase 'Emergency in (patient location); airway problem'

2) Conduct clinical reasoning and fault tracing

A. Airway:
- Confirm airway patent with end tidal CO_2 trace and chest wall rise
- Ventilator: Check SpO_2 and increase FiO_2 to 100% if needed
- Check position of breathing tube by comparing length markings at incisors with expected (recorded) length (usually 20-24cm)
- Listen for audible air leak from mouth. If present, follow protocol in **Action card 1**
- Check ventilator circuit for leaks. If concerned and not able to correct, disconnect ventilator and commence manual ventilation with self-inflating bag and 15L O_2.

B. Assess Breathing:
- Breathing tube:
  - If patient biting on tube, or coughing, consider bolus of sedation (1-2 ml of propofol and/or opiate)
  - If tube appears to be in correct place, it may be blocked by secretions. Undertake closed in line suction
  - If HME filter in place, ensure it is not water-logged/occluded. Remove and replace if necessary
  - If active/wet humidifier is being used check circuit not full of water.

C. Assess circulation: pulse, heart rate, rhythm, and blood pressure.

Reassess airway and breathing. If further concern, call Expert Support

Possible Causes

Airway:
- Blockage in tube by secretions, plastic, foreign body
- Blocked/waterlogged HME filter
- Patient biting on tube
- Breathing tube in too far (endobronchial)
- Breathing tube partially displaced (e.g. cuff leak)
- Leak from ventilator circuit (e.g. suction port open)
- Excess water in ventilator circuit from active/wet humidifier.

Breathing:
- Patient coughing/resisting against the ventilator
- Pneumothorax
- Bronchospasm
- Aspiration
- Pulmonary oedema
- Ventilator pressures in pressure control/support set too low.

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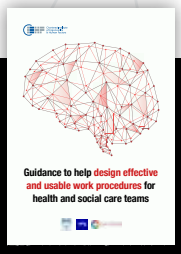

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ACTION CARD

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VENTILATOR FAILURE

1) Call for help

Use alert phrase 'Emergency in (patient location); airway problem'

2) Conduct clinical reasoning and fault tracing

A. Airway:
- Disconnect ventilator tubing from patient - leave filter attached to ET tube
- Connect self-inflating bag with 15 L oxygen and commence manual ventilation and ensure $ETCO_2$ trace and symmetrical chest wall rise.

B. Breathing:
- Assess chest for symmetrical chest rise, respiratory rate, measured tidal volumes and pressures on ventilator, end tidal CO_2 and SpO_2 values.

C. Circulation:
- Check pulse, heart rate, rhythm, and blood pressure.

Possible Causes

Power supply failure:
- plug not connected
- mains backup (generator) failure
- battery backup failure.
- Internal ventilator error.
- Wall oxygen supply failure:
  - Ventilator hose disconnected
  - Low oxygen pressure due to excess demand.

Essential steps to design work better

How to improve the design of work procedures

Create 01

- Ensure it's needed
- Involve the whole team at every stage
- Identify hazards
- Capture how your work is really done
- Ensure it's easy-to-follow

Test 02

- Ask people who will use it to test it
- Use feedback to improve it
- Repeat until everyone is happy with the procedure

Use 03

- Train people in its use
- Spend time putting it into practice
- Make sure it's easy to find
- Share it with others

Review 04

- Review regularly
- If it's not being used, understand why
- Update it if it no longer reflects how you really work

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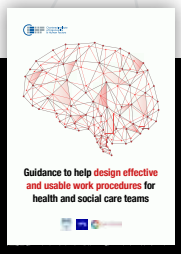
Read the full guidance on human-centred design of work procedures



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ACTION CARD
10
COVID-19

UNPLANNED EXTUBATION

1) Call for help

Use alert phrase 'Emergency in (patient location); airway problem'

2) Conduct clinical reasoning and fault tracing

A. Airway:
- Confirm lack of end tidal CO_2 trace
- If prone, turn to supine
- Optimise airway -> head tilt, chin lift, jaw thrust+/- adjuncts. Apply 15 L oxygen via face mask
- Assess for adequate spontaneous breathing from chest wall rise and SpO_2
- If inadequate spontaneous breathing call for support, commence two-person bag mask ventilation with oropharyngeal airway and prepare for emergency reintubation.

B: Breathing
- Assess chest for symmetrical chest rise, respiratory rate and SpO_2 value.

C: Circulation:
- Assess pulse, heart rate, rhythm, and blood pressure
- Check SpO_2, FiO_2, RR, haemodynamics, conscious level.

Possible Causes

- Displacement of the breathing tube.

Essential steps to design work better

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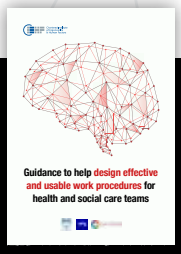

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[1] https://anaesthetists.org/Home/Resources-publications/Safety-alerts/Anaesthesia-emergencies/Quick-Reference-Handbook/PDF-version