Western General Hospitals Satellite/Surge Critical Care Unit[1]

Standard Operating Procedure for GE Aisys CS^2 Ventilators
Version 1.4

Disclaimer: These ventilators are designed for the provision of anaesthesia and not for long term ventilation of the critically ill patient and are therefore being used out-with their licensed indications. This is acknowledged on the NHS Lothian clinical risk register.

GE Aisys CS^2 Ventilators are designed for use in the peri-operative situation under the continual supervision of an experienced anaesthetic team. This guide may not be comprehensive and may need to be updated during the COVID-19 pandemic as more information is provided from GE, Royal Colleges/ASA and our personal experience. We will also adapt our use of the ventilator during different phases of the COVID-19 pandemic dependent upon use of surge capacity.

A user guide will be laminated and attached to each machine for quick reference. This document should be read in conjunction with "An Introductory guide to the AISYS CS^2 ventilator for non-Intensivists who may be expected to use this ventilator in the context of the current COVID 19 pandemic". Clinical teams responsible for ventilated patients must have undergone local induction and an ODP/medical staff with a certificate in basic anaesthesia should be available all times.

There is very limited experience nationally with using anaesthetic machines for the long-term ventilation of critically ill patients. Running low flows (less than patient MV) with soda lime may be associated with high levels of circuit moisture which may interfere with how the machine operates. With initial surge (Non-COVID), we will aim to ventilate without soda lime using higher flows. The expectation is that we will need soda lime if the required flows are greater than 10l/min. The two options then will be 6l/min FGF with soda lime or 3l/min with soda lime if hospital oxygen delivery is problematic.

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Phase 1 (Satellite ICU – non COVID patients)

***For all Neuro ICU patients requiring tight CO_2 control, please use soda lime in the circuit and initial flows of 6l/min.**

1 Prior to a ventilated patient arriving in satellite ICU, a suitable bed-space should be identified, equipment safety check performed including the Aisys CS^2 ventilator with HMEF and closed-suction within the circuit. The machine can be checked without the volatile cassette in the circuit and this reduces the time for a full check to 5 minutes. In an emergency, the machine can be used without a pre-check but arrangements should be made to transfer onto a checked machine soon as possible.

2 Appropriate alarm limits should be checked including peak pressure (set at 35cmH_2O as standard). Minute ventilation alarm should be increased from default. FiCO_2 alarm must be set at 0.5 kPa. Capnography should be monitored through the ventilator rather than the Mindray console. A backup oxygen cylinder and means of oxygenating the patient must be available.

3 There is no capability for using scavenging in the satellite ICU. This may result in unintended PEEP. The anaesthesia gas scavenging system (AGSS) must be opened to atmosphere by removing the hose connected to the AGSS and removing the visual indicator bag (if present).

4 The circle circuit should be set-up with a bacterial filter on the expiratory limb (yellow Intersurgical). An HMEF (blue Teleflex) should be attached to the patient end of the circuit, followed by a closed-suction catheter (attached to either a COETT or tracheostomy).

5 For new admissions, commence the patient on FiO2 1.0, PEEP 8-12cmH_20, tidal volume 400mls and then change to 6mls/kg according to the ventilation bedside charts. Standard ventilation mode should be SIMV PCV-VG with appropriate respiratory rate to maintain pH>7.2 / $H^+ \leq 65$ (15 is usually acceptable). FiO2, PEEP and RR can be changed according to the initial ABG which should be done either at admission or following arterial line insertion. Respiratory rate and I:E ratio are not linked and must be changed through the “More Settings” option.

6 For patients being repatriated from ward 20, commence the settings that they were on in ward 20. This will either be SIMV (change to SIMV PCV-VG) or PS/CPAP (use PSV-Pro). It is important to note that most patients who are on PS/CPAP would have received tube compensation. This is not an option when using the Aisys ventilator. An increase in pressure support may be required. Check an ABG after

30 minutes and adjust FiO_2, PEEP and respiratory rate to meet the PaO_2 and $PaCO_2$ targets that will have been set by the ICU Consultant.

7 For non-COVID patients, the Aisys ventilator can be run without soda lime (EZchange Canister Mode). "**CO_2 absorber out of circuit**" will be displayed on the ventilator monitor. To avoid CO_2 rebreathing, the gas flow-rate through the circuit will need to be at least 6-8L/min initially. In patients with a high-metabolic rate or elevated minute volume, a higher flow will be required. This will be detected by an increase in either the $EtCO_2$ or $PaCO_2$ (on an ABG) with a corresponding increase in inspired CO_2 ($FiCO_2$).

8 If $FiCO_2$ is >0.5, increase FGF by 1litre/min. If the $FiCO_2$ is not reducing at 15 minutes, increase by a further 1L/min. If >10 litres/minute are required to avoid rebreathing, soda lime should be added back to the circle and flows reduced to 6l/min.

9 The soda-lime canister must be present during the system check. Although the circle can be used without the canister, there will be ongoing small leaks. If high flows (6-8L/min) are used without soda lime, an empty canister should still be present in the circle.

10 The Aisys ventilator does not compensate for leaks within the circuit. If the leaks are greater than the fresh gas flow into the circuit, the ventilator bellows will collapse and the warning "**unable to drive bellows**" displayed. Closed suction will result in a system leak. Gas flows should be increased to 10 litres/min during procedures including closed-suctioning. The ventilator will alarm during suctioning despite this. Once suctioning is complete, the bellows should re-fill in <10 seconds, following which flows can be reduced.

11 All patients in the satellite ICU requiring sedation should be receiving either propofol or an alternative sedative such as midazolam/clonidine. Volatile agents (sevoflurane/isoflurane) should not be used. If there is a history of malignant hyperpyrexia, a "clean" machine should be used.

12 The Aisys ventilator is not intended for long-term ventilation use and is designed to be rebooted every 24hrs to ensure proper calibration, accuracy and performance. This will not be possible in critically ill patients but should be considered when a patient is stable following a review at SpR or Consultant level. Unless the patient is transitioning to external CPAP, oxygenation will be maintained using a C-circuit and assisted breaths.

13 The Aisys ventilator will operate for 49 days from its initial device check. It will reboot at this point.

14 The ventilator circuits in ward 20 are routinely changed at 7 days and this will initially be our standard with non-COVID patients. Increasing moisture in the circuit increases the risk of flow sensor/valve failure. If such a situation arises, the patient should be ventilated using either a C-Circuit or Oxylog 3000 ventilator and an alternative ventilator acquired.

15 Both the HMEF (blue) and expiratory limb filter (yellow) should be changed daily. They should be visually inspected and changed more frequently if either appears blocked or discoloured. Filter inefficiency should also be considered if $EtCO_2$ is not being cleared or peak pressures are increasing (suggesting an increase in dead space and circuit resistance).

16 Although it would not be standard practice for low risk patients, when changing either the patient or expiratory limb filters, ventilation should be paused and the COETT clamped before the circuit is broken. The procedure for this should be as follows: 1. Clamp COETT during inspiration 2. Pause gas flow 3. Perform the intervention 4. Restart gas flow 5. Unclamp the COETT.

17 Closed suction should be changed every 24 hours as per ward 20 standards.

18 If there is concern about the function of the ventilator or in the situation of sudden patient deterioration, isolate the patient from the ventilator using a C-circuit, FiO_2 1.0 with supported breaths. Immediate medical assistance should be sought.

Phase 2 (Satellite ICU and COVID Surge ICU in main theatres) – Low gas flows and soda lime in the circuit

With the opening of the surge ICU, the hospital-wide demand on oxygen delivery may negate the use of higher flows (>6l/min). All patients within satellite ICU (COVID-Negative) and the COVID-positive surge ICU should be considered a low-flow (3l/min) circuit with soda lime.

Full PPE with FFP3 mask should be worn by all team members.

1. Ventilation of COVID positive patients presents an increased risk to staff despite use of PPE including a fitted FFP3 mask. COVID positive or suspected COVID positive patients should be ventilated in theatres. Scavenging must be working and the expiratory port from gas monitoring attached to either the expiratory limb of the circuit or scavenging.

2. A full machine check should be performed prior to use (as in **Phase 1**). If a volatile agent is to be used for sedation, the check must be performed with the volatile cassette in the circuit.

3. All patients must have an HMEF (blue) at the distal end of the circuit and a viral/bacterial filter (yellow) on the expiratory limb. Side-stream capnography must be from the ventilator side of the HMEF.

4. Any planned breaks in the circuit must be preceded by COETT clamping followed by pausing gas flow (procedure as previously described). Ventilation must only be restarted once the integrity of the circuit is confirmed.

5. For new COVID-positive admissions, commence the patient on FiO2 1.0, PEEP 12cmH_20, 400mls tidal volume and then change to 6mls/kg according to the ventilation bedside charts. Standard ventilation mode should be SIMV PCV-VG with appropriate respiratory rate to maintain pH$\geq$7.20, $H^+ \leq 65$ (24 is usually an acceptable initial parameter). FiO2, PEEP and RR can be changed according to the initial ABG but it is expected that COVID patients will require high PEEP (12-20cmH_2O). **Respiratory rate and I:E ratio are not linked and must be changed through the "More Settings" tab.**

6. The ventilator set-up for COVID positive patients should include canister soda-lime. Initial fresh gas flow should be either 3 litres/minute or 6 litres/minute dependent upon hospital wide oxygen demand. The soda lime will need changing every 8-24 hours or sooner if the patient has an elevated metabolic rate. This will be detected by an increase in the either the $EtCO_2$ or $PaCO_2$ (measured using an ABG) with a corresponding increase in inspired CO_2 (F_iCO_2).

7. COVID positive patients can be ventilated with soda lime out of circuit (empty canister), using elevated flow rates (at least 6-8 litres/min initially). However, in the event of us needing to ventilate COVID patients in a surge ICU, the expected oxygen delivery demand may outstrip capability. These patients will also have an elevated MV and metabolic oxygen demand. Flows >10L/min may be required.

8. All COVID patients will be initially sedated with propofol. Should propofol supply become limited, volatile anaesthetic agents can be used (sevoflurane/isoflurane). If used with an opioid infusion, a MAC of 0.3-0.5 should be adequate unless deeper sedation is required for either ventilator dyssynchrony or alongside neuromuscular blockade. The potential detrimental effects of long-term sedation have not been studied. We will need to use ET control to avoid MAC increase when higher flows are required.

9. The Aisys ventilator does not compensate for leaks within the circuit. If the leaks are greater than the gas flow into the circuit, the ventilator bellows will collapse and the warning “unable to drive bellows” displayed. Closed suction will result in a system leak. When performing suction at low gas flows, temporarily increase fresh gas flows to 10l/min during the procedure. If the ventilator bellows collapse on occasions other than suctioning, this should result in a circuit check to exclude leaks (push and twist all connections, check cuff pressure using a manometer).

10. At low flows, if the patient’s oxygen demand outstrips supply, the FiO_2 delivered by the ventilator will fall. In this situation, increase the flow by 0.5L/min and recheck FiO_2 after 5 minutes.

11. Breaks in the circuit should be kept to a minimum. The circle should not be routinely replaced in COVID-positive patients.

12. Replacing both the closed suction/patient HMEF are higher risk procedures and should not be done routinely (to be confirmed with IPC team). If either needs replacing, the COETT should be clamped and fresh gas flow paused. Fresh gas flow should only be restarted when the integrity of the circuit is confirmed. The patient should either be deeply sedated or paralysed to reduce the risk of coughing.

13. Increased moisture production with low-flows and soda lime could be problematic. In this situation, consider increasing flows +/- removing the soda-lime from the canister. Flows should be increased every 4 hours to 10l/min for 5 minutes. This will help to reduce the moisture in the circle.

14. There will be “rain-out” within the circle and this should be emptied. This may be seen on visual inspection but may also be suggested by oscillations in the pressure/flow waveforms. This is especially important as the oscillations may be sensed as patient effort and a supported breath triggered. The circuit should be only broken proximal to the patient HMEF once the COETT has been clamped and fresh gas flow paused.

15. The proximal expiratory filter (yellow) may become wet and there will be increased resistance within the circuit. This may also reduce its viral filtering efficiency. The filter should initially be replaced every 24 hours (to be confirmed with IPC). Ideally this should be timed with replacement of the soda lime canister. With increasing experience we may find that routine changes will not be necessary.

16. The soda lime will need to be changed approximately every 8-24 hours. This will vary depending on the metabolic rate of the patient and fresh gas flow used. There will be a brief drop in circuit pressure when the canister is disengaged and again

when it is re-engaged. To negate the potential effect of PEEP loss, increase the fresh gas flow to 10l/minute during the procedure.

17. In a patient on FiO2>0.6 and PEEP ≥12, the brief de-pressurisation associated with soda-lime canister change could be detrimental to the patient's oxygenation. These patients should have their COETT clamped during canister change. The time to perform the procedure should be kept to a minimum.

18. The condenser reservoir should be drained every 24 hours or more frequently if visually required. This will result in loss of PEEP. The COETT should be clamped and fresh gas flow paused prior this procedure. Fresh gas flow will need to be increased to 10l/min following the procedure until the ventilator bellows re-fill.

19. Our understanding of how to use the Aisys CS^2 ventilator with reference to resource utilisation and optimisation of patient respiratory physiology will undoubtedly change with experience. This document will be updated regularly and changes communicated with medical, nursing and technical staff.

Appendix

1. Local procedures should be followed for device cleaning and decontamination. Further information is available from GE. Internal decontamination should only be required if bacterial/viral filters have not been used appropriately. https://cleaning.gehealthcare.com

2. SIMV PCV-VG – delivers a set rate of pressure-controlled breaths with a guaranteed volume to the patient. The patient can breathe spontaneously between mandatory breaths. Pressure support (typically 5-10cmH_20) can be used to support spontaneous breaths. This setting is similar to the autoflow mode that is used within Ward 20, in that it will adjust inspiratory pressure needed to deliver the set tidal volume, ensuring that the lowest pressure is used. To ensure that the maximum pressure delivered is 30cmH_2O, peak pressure alarm (Pmax) must be set at 35cmH_2O. When a patient is ready for weaning, SIMV PCV-VG can be used initially by reducing the mandatory RR.

3. PSVPro Mode – pressure supported ventilation with an apnoea backup. The clinician should set the pressure support and PEEP levels. The tidal volume is determined by pressure, lung compliance and patient effort. An apnoea mode is provided if the patient stops breathing. The clinician must adjust the inspiratory pressure, respiratory rate and inspiratory time.