



COVID-19 UPDATE

GUIDANCE ON THE REPURPOSING OF ANAESTHETIC MACHINES AS MECHANICAL VENTILATORS DURING COVID-19 SURGE

Version 1 – 11 June 2020

This is not an easy fix and comes with a number of important considerations.

There are two underpinning ethical considerations:

1. First do no harm
2. Do the most for the most

This is a dynamic document which changes as the NICD case definition, the COVID related regulations are promulgated and the pandemic evolves. It is effective at the time of issue and may be updated or changed at any time.

The key principles for the use of anaesthetic machines as mechanical ventilators during the surge phase include:

1. The decision to proceed on this route is one that should not be taken lightly. If you are not absolutely certain that you can ensure safe patient care, this should not be an option in your facility
2. The decision to proceed on this route should only be considered when all other equipment resources have been depleted
3. This is intended to be a short term solution owing to the expertise and terminal cleaning required for these environments and machines. Ideally patients who require longer term ventilation should receive this in the critical care unit
4. Adequately trained/experienced nursing staff are available to look after this patient in the theatre complex
5. 24/7 anaesthetist presence in the theatre complex where these patients will be looked after
6. Hospital has identified all necessary and additional infrastructure capabilities and requirements that will be needed during their unique COVID-19 surge / disaster plan
7. The instruction to make use of the dedicated area/theatre as a temporary solution should come from the hospital command structure (HOC) as part of the hospital specific disaster plan

Repurposing theatre infrastructure, equipment and staff for additional capacity as needed

1. Theatre staff repurposing:

- 1.1. **Deputy Nursing Managers** for theatre can be deployed to assist the hospital team with logistical management e.g. theatre slate planning and approval, resource planning, stock distribution, CSSD logistics to support the hospital as well as other nursing support

- 1.2. Theatre unit managers or SPNs** who function as a second in charge to the theatre manager, should remain in the theatre complex as the contact and logistical manager for urgent and emergency cases
 - 1.3. Recovery staff and anaesthetic staff** who are qualified in ICU or operating room science and have recently worked as an anaesthetic nurse or recovery nurse, can be relocated to assist in the ICUs under supervision of an ICU trained nurse and upskilled where appropriate to work on their own – or help to look after these patients when nursed in the theatre complex, under direct supervision of an ICU nurse
- 2. Critical Care staff repurposing**
 - 2.1. Critical care unit manager** should redeploy some of the trained/experienced PNs to work in the theatre complex in combination with the dedicated theatre staff using a team approach
- 3. Anaesthetist Cover**
 - 3.1.** A team of anaesthetists to ensure 24/7 cover – such that at least one anaesthetist is available in the event that patients are being ventilated using the anaesthesia machines. The ratio should be 1:4 to 1:5 maximum as anaesthetists will be looking after patients from a critical care perspective¹
 - 3.2.** Anaesthetist remains responsible for the respiratory management / anaesthetic machine management of the patients nursed in the theatre complex
- 4. Additional infrastructure capabilities of Theatre**
 - 4.1.** In the event of the ICU surge requiring additional ventilators and space, and there is not adequate space in the hospital, patients may be moved into the theatre department and nursed within an operating room
 - 4.2.** The operating theatre will be managed as an ICU isolation room and access to the operating room has to be controlled and limited
 - 4.3.** Spaces between beds will have to be at least 3 meter measured from side to side
 - 4.4.** All non-essential stock should be removed from the operating room to prevent contamination
 - 4.5.** At least one operating room should be used for emergency theatre cases and should be the operating theatre closest to the theatre entrance
 - 4.6.** At least one operating room should be used for COVID-19 emergency theatre cases to prevent staggering of infected patients at the end of the emergency theatre cases
- 5. Guidance on the use of anaesthesia machines as ICU ventilators**

Use of an anaesthetic machine as a ventilator in treatment of critical illness, such as in the event of a COVID-19 surge, outside its intended use, is considered off-label use but may be essential due to ventilator availability.²

 - 5.1. Important considerations:**
 - a) An **anaesthesia professional/anaesthetist** should be **immediately available at all times** to manage the use of the anaesthetic machine as an ICU ventilator; the

¹ SASA overview of document, e-mail to C. Griessel [Online]. 9 June 2020. Available e-mail: Lance@globalmicro.co.za

² <https://www.gov.uk/drug-device-alerts/anaesthetic-machines-off-label-use-during-the-covid-19-pandemic-mda-2020-012>

anaesthetic assistant/nurse is trained to manage anaesthetic machines and should be assisting and continuously present in the operating room while the patient is being ventilated. Vital signs monitors are permanently fixed to the anaesthetic machine which is different from ICU; this will require additional orientation of the ICU nursing practitioners, leading to additional stress³

- b) **Anaesthetic machines converted for the purpose of ventilating patients should ideally be used inside an operating room;** the anaesthetic machines are considerably bigger than the ICU ventilator, which will influence the positioning of the machine behind/next to the patient and might not be practical. The operating rooms are appealing as isolation rooms with anaesthetic machines readily available for use and connected to gas supplies
- c) **Off-label use** of anaesthetic machines due to the nature of the COVID-19 crisis will not be objected to by the FDA⁴
- d) Follow the **instructions for use** (IFU), and the additional off-label use information from the manufacturer. This may include more regular maintenance, testing or calibration
- e) **Adequate training** of clinicians to ensure that they are familiar with the unique performance characteristics of the device; the device interface and alarm system, controls, functionality, configurations and theory of operation before using these devices
- f) **Software interface differences** may require confirmation of the settings to deploy as ventilators and manufacturer guidance and support needs to be used⁵
- g) **Anaesthetic agent residual amounts;** All consumable items must be replaced before placing a patient on the anaesthetic machine ventilator. Appropriate filters must be in place per the diagram. Wherever possible the machine should be flushed at 10l / min for 60 min before using the ventilator to prevent the possibility of malignant hyperthermia where a history may not be available
- h) **Prevention of CO₂ rebreathing;** ⁶ Anaesthetic machines should always be operated with CO₂ absorber attached, except when they are being changed, whereas ICU ventilators do not require CO₂ absorbers. If inspired CO₂ levels are rising, replace the soda lime according to the manufacturer's instructions. SASA recommends, in order to prevent the rapid exhaustion of soda lime and buildup of significant moisture in the circuit, fresh gas flows up to 150% of minute volume are recommended. Staff operating these units should be given guidance as to the use of FiO₂⁷ monitoring and the potential for this being very different from the set oxygen concentration⁸
- i) The use of anaesthesia devices for ICU ventilators **for paediatric or neonatal patients are discouraged**

³ <https://www.asahq.org/in-the-spotlight/coronavirus-covid-19-information/purposing-anesthesia-machines-for-ventilators>

⁴ https://sasaapi.sasaweb.com/Newsletters/Document/TheUseofAnaesthesiaVentilatorsintheCovid-19Crisis7April202018h00_637218715635227958.pdf

⁵ <https://www.draeger.com/Library/Content/Checklist-anaesthesia-devices-for-long-term-ventilation.pdf>

⁶ Off-Label Use: GE Healthcare Anesthesia devices for ICU Ventilation, e-mail to C.Griessel [Online], 2 April 2020, Available e-mail: f.caldeira@medhold.co.za

⁷ https://en.m.wikipedia.org/wiki/Fraction_of_inspired_oxygen

⁸ https://sasaapi.sasaweb.com/Newsletters/Document/TheUseofAnaesthesiaVentilatorsintheCovid-19Crisis7April202018h00_637218715635227958.pdf

- j) **Audio alarm and settings;** Anaesthetic machines are designed for supervised use as the audio alert level is not similar to the ICU setting, not providing alternative methods of continual status monitoring, therefore it is recommended that all alarms are enabled all the time and that patients are not left unattended while being ventilated
- k) **Nebulisation and active humidification;** Anaesthesia ventilators do not have inline nebulisation facilities – Active humidification is not possible and may cause damage to the equipment. – **An HMEF is required for ALL patients ventilated using anaesthesia units**
- l) **Leak Compensation;** Anaesthesia ventilators do not compensate for circuit leaks and anaesthetists and operators have to be trained to monitor bellows position to adjust fresh gas flows when required
- m) **Increased consumption; Dependent on flow choice,** anaesthesia ventilators may require increased oxygen use which has to be planned for
- n) **Removal of or unplugging of** vaporisers, nitrous oxide cylinders and pipeline hoses is important to ensure patient safety – ensuring no nitrous oxide or volatile agent is inadvertently delivered to the patient
- o) **Scavenger system;** is not required if inhalation agent delivery is not planned and the gas analyser sampling line is filtered; disconnected from the hoses coming from the breathing system and ventilator OR the scavenger reservoir bag should be removed if it is a closed-scavenger system⁹
- p) **Cleaning of the anaesthetic machine:** Viral filters are used as directed and this will mitigate the risks of passing COVID-19 virus to a subsequent patient. Usual hospital procedures for cleaning anaesthetic machines **between patients should** be followed including wiping the external surfaces and replacing disposables.¹⁰¹¹¹² None of the manufacturers are recommending cleaning procedures that involve the internal components of the machine as long as high quality filters are used with each patient to prevent exhaled virus from entering the machine and gas sampling lines are connected to the machine side of the filter. *If there is evidence that the internal surfaces of the machine have become contaminated, the manufacturer's recommendation needs to be followed*¹³

5.2. Preparation for conversion of anaesthetic machines to ventilators when a surge of COVID-19 patients is experienced and ICU ventilation no longer possible:

It is important that, as part of the Hospital Medical Incident Management COVID-19 Preparedness framework, the hospital establishes a management and doctor structure

⁹ <https://www.asahq.org/in-the-spotlight/coronavirus-covid-19-information/purposing-anesthesia-machines-for-ventilators>

¹⁰

<http://intranet/sites/Policies/Records/Cleaning%20and%20Disinfection%20Bed%20and%20Patient%20Environment.pdf>

¹¹ <http://intranet/sites/Policies/Records/Disinfection%20Guidelines.pdf>

¹²

<http://intranet/sites/trainingcontent/Nursing%20Procedures%20Published/Theatre%20Procedures/Theatre%20Procedures%202019-03-01/Decontamination%20of%20a%20theatre%20after%20a%20list.pdf>

¹³ <https://www.apsf.org/faq-on-anesthesia-machine-use-protection-and-decontamination-during-the-covid-19-pandemic/#cleaning>

which includes the nomination of an in charge clinician for theatres from the affiliated doctors in the hospitals.

The doctor in charge with the theatre manager will be responsible to **negotiate with anaesthetists regarding assistance with the conversion** of anaesthetic machines to ventilators as well as **oversight of the patients** and the scheduling of possible rosters to cover the shifts required to ensure the **availability of an anaesthetist at all times**.

At least **one operating room** needs to be available for **emergency procedures**.

At least **one operating room** needs to be available for **COVID-19 patients** who require emergency or urgent procedures.

Anaesthetic assistants who completed the CPD courses in Anaesthetic and Recovery Room Nursing for RNs and ENs should be considered for orientation in ventilation of the COVID-19 patient in the operating room environment under the supervision of an anaesthetist and qualified ICU Registered Nurse.¹⁴

5.3. Table of ventilator specifications by anaesthetic machine:¹⁵

Make/Model	Ventilator Drive	P _{MAX}	RR _{MAX}	Maximum PEEP	V _T /MV _{MAX}	Spirometry/ Compliance/ Sensing
Draeger Apollo	E-Piston	70	100	20	1400/50	Y/Y/Y
Draeger Fabius	E-Piston	70	60	15	1400/25	N/Y/Y
Draeger Perseus	E-Blower	80	100	35	1500/50	Y/Y/Y
GE Aisys and Aisys C ₂	P-Bellows	100	100	30	1500/120	Y/Y/Y
GE Avance and Avance C ₂	P-Bellows	100	100	30	1500/120	Y/Y/Y
GE Carestation 6000 Series	P-Bellows					Y/Y/Y
Getinge Flow-i	P-Reflector	80	100	50		Y/Y/Y
Mindray Advantage	P-Bellows	100	100	30	1500/30	Y/Y/Y

P- Pneumatic. E-Electrical

5.4. Practical advice for the use of anesthesia ventilators as noted in the “SASA guidelines on the use of anesthesia machines as ICU ventilators”¹⁶:

- Any concerns with the machine or ventilation should be escalated to anaesthetic staff who have familiarity with the equipment
- Leave the machine in ventilator mode – do NOT switch to bag mode

¹⁴ <http://intranet/sites/trainingcontent/Formal%20Course%20Prospectuses/Forms/Topic.aspx>

¹⁵ https://sasaapi.sasaweb.com/Newsletters/Document/TheUseofAnaesthesiaVentilatorsintheCovid-19Crisis7April202018h00_637218715635227958.pdf

¹⁶ https://sasaapi.sasaweb.com/Newsletters/Document/TheUseofAnaesthesiaVentilatorsintheCovid-19Crisis7April202018h00_637218715635227958.pdf

- c) Vaporisers should be removed from the anaesthesia machine when used as a critical care ventilator
- d) Do NOT adjust or use the APL valve – this is for manual ventilation only
- e) Total gas flow should be at LEAST 6 litres per minute or 150% of the minute volume, whichever is greater – this is to prevent rebreathing and rapid soda-lime exhaustion
- f) The anaesthetic machine MUST be used with an HME/F filter which must be changed every 24 hours
- g) Provided high quality filters are used, scavenging is not required
- h) High inspiratory pressures, High FiO₂ requirement or high ETCO₂ should prompt a filter change before consideration given to proning patient
- i) Visible water collecting in the circuit must be drained – this is to prevent increased resistance to ventilation and bubbling caused by gas flow which may be sensed as a patient inspiratory effort leading to increased ventilation and dyssynchrony
- j) Soda lime must be changed every 24 hours – should be done by anaesthetic staff
- k) Suctioning may empty the bellows – please check these after suctioning and increase gas flow
- l) If the bellows are empty – the oxygen flush can be used to fill them BUT this is NOT recommended. Also, do NOT use to give patients 100% oxygen – the flow and pressure delivered are too high and may cause lung damage
- m) The machine will alarm for a checkout every 24hrs. This can be ignored when a patient is on the machine, but needs to be performed before a new patient is connected to the machine
- n) Dependent on anaesthesia workstation ventilator capability, patients may require deeper levels of sedation when ventilated with anaesthesia machines compared to traditional modern ICU ventilators. A significant number of modern anaesthesia ventilators are able to provide ICU modes of ventilation
- o) These machines should be reserved for patients who are easy to ventilate
- p) It is advisable to have at least one anaesthetist au fait with anaesthesia ventilators available at all times to assist with troubleshooting should the need arise**

5.5. List of quick tools for easy reference:

GE Aisys CS2 and GE Aisys Gen 1 Conversion information (Request for information regarding the off-label use of GE Healthcare anaesthesia devices for ICU ventilation – 23 March 2020): <https://www.gehealthcare.com/-/jssmedia/3c655c83bd6b427e9824994c12be0da5.pdf?la=en-us>

APSF/ASA guidance on purposing anaesthetic machines as ICU ventilators including a quick guide tool: <https://www.asahq.org/in-the-spotlight/coronavirus-covid-19-information/purposing-anesthesia-machines-for-ventilators>

APFSA FAQ on Anesthesia machine use, protection, and decontamination during the COVID-19 pandemic: <https://www.apsf.org/faq-on-anesthesia-machine-use-protection-and-decontamination-during-the-covid-19-pandemic/#cleaning>

SASA Guidelines on the use of anaesthesia machines as ICU ventilators during COVID-19 emergency:

SASA Quick reference: Setup and monitoring instructions: Anaesthetic machine as an ICU ventilator¹⁷:

Quick Reference: Setup and Monitoring Instructions Anaesthesia Machine as an ICU Ventilator

SETUP

- Gas Supply check
 - Check connection to Central Gas supply ~4kPa.
 - Check backup oxygen cylinder is full.
 - Disconnect nitrous oxide hose from supply.
- Scavenger
 - Connect outlet to hospital scavenger system.
- Vaporizers
 - Remove or empty vaporizer (unless required for sedation).
- Configure machine with disposables
 - Filters
 - HMEF on airway, gas sampling on machine side.
 - Second (HEPA) filter on expiratory limb.
 - Large (Adult) reservoir bag
 - Gas analyser in line machine side of filter or side stream from filter
 - Oxygen and carbon dioxide
- Machine check self test
 - Compliance test with circuits and filters installed (repeat test if changed).
 - Confirm passes self test with no errors
- Check alarms and set appropriate limits for ICU patient, ensure volume set high.
 - Default limits may be different per machine than required in ICU patients
 - Inspired CO₂ alarm at 5 mmHg(0.6kPa).
 - Expired CO₂ alarm increased to allow for permissive hypercapnoea.
 - Adjust high and low pressure alarm limits.
 - Adjust Minute Volume, rate and FiO₂ alarm appropriate to patient.
- Set APL Valve to 0cm H₂O

PRIOR TO USE

- Ensure
 - Manual ventilation device readily available
 - Suction connected and available
 - Machine preferably powered by UPS power and generator backup

MONITORING SCHEDULES

- Continuous:** Alarm monitoring enabled and mandatory
- Hourly check**
 - CO₂ Absorbent
 - Inspired Oxygen concentration
 - Inspired and expired CO₂ concentration
 - Agent concentration if applicable as well as Vaporizer if agent being used.
 - Humidity and secretions (Filters and water traps)
 - Inspiratory Pressure
 - Tidal volume
 - Spirometry
- 4 Hourly Check**
 - HMEF change/ check
 - Increase FGF to MV or above for 15minutes
- 24 Hourly Check – Machine Self test***

**Anaesthesia machine WILL NOT provide ventilation during the self-test. An alternate ventilation strategy that can be maintained for several minutes is required. Consider transport ventilator to maintain PEEP if manual ventilation bag not likely to be successful. Power to the machine should be cycled between every patient and at least every 25 days.*

INITIATE THERAPY

- Fresh Gas Flow (FGF) Options
 - Option 1: Low fresh gas flow to conserve oxygen
 - Preserves humidity
 - CO₂ absorbent must be available and maintained
 - Inspired CO₂ Alarm must be set to 5 mmHg(0.6kPa)
 - Option 2: Fresh gas flow = Minute Ventilation
 - CO₂ absorbent in place but does not need to be replaced (Increase FGF if inspired CO₂ present)
 - Humidification essential (HMEF)
- Setting Oxygen Concentration
 - Electronic flowmeters – set required concentration (FiO₂)
 - Monitor delivered FiO₂
 - Mechanical flowmeters
 - Air/Oxygen mix to deliver O₂ concentration (use table or oxygen analyser) and flow required.
 - Inspired oxygen concentration must be monitored especially when using low flows – it will be less than set concentration
- Set Ventilator according to patient needs to Critical Care principles advice per patient
 - Ventilation mode
 - Rate, Volume/ Pressure
 - I:E Ratio
 - PEEP
- Start Ventilator
 - Select spirometry loop if available
 - Note Pressure and flow waveforms
 - Record monitored values

- 4 Hourly Check**
 - HMEF change/ check
 - Increase FGF to MV or above for 15minutes
- 24 Hourly Check – Machine Self test***

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¹⁷ https://sasaapi.sasaweb.com/Newsletters/Document/TheUseofAnaesthesiaVentilatorsintheCovid-19Crisis7April202018h00_637218715635227958.pdf

6. CSSD capacity:

- a. In the event of additional capacity requirements, the assumption would be that the elective cases, especially cases such as replacement surgery, would free up staff capacity as well as process capacity in CSSD
- b. Where linen packs, gowns and instruments sets become challenging to process, disposable options should be investigated
- c. Additional capacity has to be freed up to assist with the processing of:
 - Ventilator components
 - Antimicrobial soap containers and pump dispensers
 - Bag Mask Valve devices
 - Laryngoscope blades

7. Please be reminded of standard precautions that must be continuously applied and maintained by all health care workers.¹⁸

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