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REVIEW

Supplement 2

Reinvention of an academic anaesthesiology department during pandemic times: lessons learnt and adapting to a "new normal"

Using GE Anesthesia Machines for Long Term Ventilation

Anesthesia Machines have a different working principles and operating modes than ICU ventilators. Personnel unfamiliar with anesthesia equipment must be trained and complete the instructions for use.

BEFORE CONNECTING A PATIENT

1. Complete circuit check
2. Make sure to flush out residual anesthetic agent vapor to lessen the risk of malignant hyperthermia
3. Restart machine prior to initiating a patient for long term ventilation
4. Ensure proper connection of ventilation hoses, anti-microbial and heat-moisture exchange (HME) filter (at Y-Piece), manual breathing bag, water traps, gas sampling line (on machine side of anti-microbial HME filter)
5. Check that the device is able to generate gas flow and pressure at the patient connector
6. Make sure that CO2 and O2 monitoring is activated
7. Make sure the inspiratory CO2 alarm is activated.
8. Disable Sample Gas Return, including disconnecting the tube connecting the gas monitor to the device.
9. All volatile agents and N2O lines should be disconnected to prevent accidental administration

BACK UP EQUIPMENT NEEDED

1. Back up Manual ventilation device (ambu-bag) should always be immediately available
2. There should always be an alternative adequate oxygen source available

TESTS, MAINTENANCE

1. Daily
    a. reboot/restart / power cycle
        i. Aisys, Avance, Aespire, Aestiva machines will shutdown after 49 days without reboot
    b. machine test/checkout
        i. accuracy of delivered volumes may suffer if no checkout within 24h

    NOTE: requires disconnect the patient from the machine and ventilate manually

SPECIAL ATTENTION

1. Breathing Circuit
    a. Unidirectional valves which may prevent the release of pressure from the patient connection; for example, if the expiratory breathing tube is occluded
    b. devices will cut off inspiratory flow if prolonged pressure scenarios occur, but do not have the ability to immediately relieve pressure in case of an obstruction.
    c. inspiratory and expiratory resistance may be higher than in ICU ventilators.
        i. --> Ensure patients are suitable for anesthesia machine ventilation
    d. Long-term use of the circle system may result in excess moisture built up and condensation in the breathing system and device --> periodically monitor the breathing system and drain water if needed

        Reduce excess moisture buildup by
        i. using at least 150% of MV of fresh gas flow
        ii. placing a heat-moisture-exchanger (HME) at the Y-piece

    e. Similar looking patient connection ports, esp. machines with the ACGO option. --> there is a risk of incorrectly connecting patient hoses, making ventilation impossible

2. Manual Ventilation ("Bag Mode")
    a. in this mode any ventilation must be provided manually using the equipped bag
    b. in this mode the APL valve determines the maximum pressure
        i. Too low of an APL setting may result in no flow actually delivered to the patient during bag mode
        ii. Too high of an APL setting may result in barotrauma.
    c. Consider placing the device in manual ventilation mode, if a closed suction routine is required (closed suctioning may cause system alarms)
3. CO_2 Absorber
    a. Never operate the machine without CO2 absorber to ensure that the patient does not inhale CO2
    b. detection of exhausted absorber: absorbent color changes to purple and/or detection of inspiratory CO2 (make sure to activate the inspiratory CO2 alarm)
4. Fresh Gas Flow
    a. Use high fresh gas flows of at least 150% of the minute volume of the patient,
        i. --> the chance of lower FiO2 is minimized
        ii. --> prevents build-up of excessive moisture
5. Humidification
    a. Passive Humidification is recommended by using an HME filter at the Y-piece.
    b. Active Humidification is not recommended
6. Ventilation Modes
    a. anesthesia machines will not automatically switch to mechanical modes in the event of apnea, when the patient is first connected, or in critical device failure
    b. during critical device failure
        i. the machine may provide 100% oxygen flow (Alternate O2, "Alt O2")
        ii. --> Ensure the Alt O2 flow setting is adequate to provide oxygenated gas to the patient prior to starting mechanical ventilation.
    c. Ventilation mode names may be similar to ICU ventilator but have slightly different meanings
    d. anesthesia machines are not designed for NIV (no leak compensation)
    e. if NIV must be used, use CPAP + PSV mode
7. Scavenger extract flow must be adequate, otherwise unintended PEEP may occur.
8. Nebulized drug delivery (e.g.with pneumatic nebulizer) is not recommended, as there is no compensations for external flows added.

Using Draeger Anesthesia Machines for Long Term Ventilation

Anesthesia Machines have a different working principles and operating modes than ICU ventilators. Personnel must be trained and complete the instructions for use.

BEFORE CONNECTING A PATIENT

1. Restart machine prior to initiating a patient for long term ventilation
2. Ensure proper connection of ventilation hoses, anti-microbial filter (at Y-Piece), manual breathing bag, water traps, gas sampling line (on machine side of anti-microbial filter)
3. Check that
    a. the device is able to generate gas flow and pressure at the patient connector
    b. by unblocking the patient connector, the pressure can be released and gas is flowing out
4. All volatile agents and N2O lines should be disconnected to prevent accidental administration
5. Make sure the inspiratory CO2 alarm is activated.
6. Flush out residual anesthetic agent vapor to lessen the risk of malignant hyperthermia

BACK UP EQUIPMENT NEEDED

1. Back up Manual ventilation device (ambu-bag) should always be immediately available
2. There should always be an alternative oxygen source available

TESTS, MAINTENANCE

1. Regular System Test
2. requires disconnect, manual ventilation and up to 8 minutes.
    a. for the test set the APL valve to a high value. Make sure to reduce it after the test
    b. frequency of system test
        i. recommended: every 24h
        ii. When this is not feasible 72 hours is acceptable,
        iii. but beyond that systems may malfunction.
3. Regular Inspection of Machine and Accessories
    a. at least every 12h
    b. check for and fix if needed
        i. Exhausted CO2-absorber,
        ii. full gas sampling water trap (even with HME and high flow)
        iii. standing water in breathing hoses and
        iv. excessive condensation at filter that may lead to increased resistance

SPECIAL ATTENTION

1. <u>Same size connectors</u> are used throughout the machine
    ➔ there is a risk of incorrectly connecting patient hoses, making ventilation impossible
2. <u>MAN/SPON (Manual or Spontaneous Ventilation)</u> – unique to anesthesia machines
    a. automatically starts when the ventilator fails
    b. during MAN/SPON mode only, the APL valve determines to which level the airway pressure rises from fresh gas flow alone (i.e., PEEP)
        i. Too low of an APL setting may result in no flow actually delivered to the patient during MAN/SPON mode
        ii. Too high of an APL setting may result in barotrauma.
        iii. The APL valve activates automatically upon ventilator failure
            ➔ set it appropriately for the patient, even in mechanical ventilation
3. <u>CO_2 Absorber</u>

   a. Never operate the machine without CO2 absorber to ensure that the patient does not inhale inspiratory CO2 even in the case of errors, such as problems with the fresh gas supply and/or delivery.
   b. Never operate the anesthesia machine without a CO2 absorber, except when exchanging a used absorber.
   c. detection of exhausted absorber: absorbent color changes to purple and/or there is inspiratory CO2 (make sure to activate the inspiratory CO2 alarm)
4. Fresh Gas Flow
   a. Use high fresh gas flows of at least 150% of the minute volume of the patient,
      i. --> only limited rebreathing and therefore the absorber will last a long time.
      ii. --> the chance of lower FiO2 is minimized
      iii. --> prevents build-up of excessive moisture
   b. Low Fresh Gas Flow can cause the following:
      i. Excessive condensation in breathing system and patient hoses, which may accumulate to a point where it impairs the therapy
      ii. CO2-absorber has to be exchanged more frequently
      iii. Large difference between the set fresh gas oxygen concentration and the measured inspiratory oxygen concentration (FiO2)
      iv. Removing the bag in low fresh gas flow circumstances will allow entrainment of room air
5. Humidification
   a. Passive Humidification is recommended by using an HME filter at the Y-piece.
   b. Active Humidification is not recommended, but if required refer to the full Draeger recommendations document
6. Ventilation Modes
   a. Pressure Controlled Ventilation (PCV) is preferable (because leakages are not compensated for in VCV, volume controlled ventilation)
   b. anesthesia machines are not designed for NIV (no leak compensation)
   c. anesthesia machines will not automatically switch to mechanical modes in the event of apnea, when the patient is first connected, or in critical device failure
7. Scavenger extract flow must be adequate, otherwise unintended PEEP may occur.
8. Nebulized drug delivery (e.g.with pneumatic nebulizer) is not recommended, as there is no compensations for external flows added.
9. User Interface cannot be locked --> ensure no unauthorized changing or switching off of ventilation.