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Use of Bi-level devices as invasive ventilators: guidelines for clinicians

Advisory on the Use of ResMed VPAP ST

(ResMed, Australia; ResMed USA, San Diego)

Because of an automatic shut-off feature in the ResMed bilevel (S9 VPAP and AirCurve), these devices should NOT be used for invasive ventilation unless no other options exist.

The ResMed VPAP ST is designed to be a *noninvasive* ventilator. Incorporation of supplemental oxygen at > 15 LPM into the circuit anywhere distal to the blower should be undertaken with extreme caution.

At a set CPAP or EPAP > 10 cmH_2O, oxygen flows > 15 LPM in a circuit with a standard exhalation port can result in an unanticipated device shut-off and patient harm. This shut-off does not occur at EPAP ≤ 10 cm H_2O or when O_2 flow < 15 LPM.

At supplemental oxygen flows of 15 LPM, the maximum achievable FiO_2 will be no higher than 60%. If a patient requires FiO_2 > 60% or PEEP > 10 cmH_2O, the use of another brand of bilevel or a conventional invasive ventilator should be considered.

Exercise extreme caution when EPAP requirements exceed 10 cmH_2O and FiO_2 requirements exceed 60%!

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Mount Sinai Health System

Current Working Guidelines – Subject to Revision

These current working guidelines are subject to revision. It is expected this document will be updated and re- released as additional experience is accumulated.

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This document should be used as a clinical adjunct to the protocol "Repurposing bi-level ventilators for use with intubated patients while minimizing risk to health care works during insufficient supply of conventional ventilation for patients with COVID-19" and is shared with our health care colleagues to increase knowledge about potential solutions to increase the capacity and access to mechanical ventilation during the COVID-19 crisis. Icahn School of Medicine does not warrant the contents or effectiveness of the protocol, and the use and implementation of this protocol should be first reviewed and evaluated with each hospital's medical staff.

QUICK GLANCE: POTENTIAL CANDIDATES FOR USE OF BILEVEL FOR INVASIVE VENTILATION

To be followed for support of intubated ICU patients if there is a crisis shortage of ventilators

Ideal initial candidates for bilevel ventilation if there is a crisis induced shortage of ventilators are patients with either:

- Stable or improving P/F ratio

or

- Decreasing or stable ventilator requirements

We do not recommend use in newly intubated patients unless no other ventilators are available. Newly intubated patients should be reassessed and considered for transition to ResMed VPAP-ST once they are stable, as detailed in Table 1.

Table 1: Criteria

Parameter on Conventional Ventilator	Acceptable Limit
FiO_2	≤ 85% (<60% for ResMed VPAP ST or AirCurve)
PEEP*	≤ 15 cm H_2O (<10 cm H_2O for ResMed VPAP ST or AirCurve)
Driving pressure: ($P_{Plateau}$ – PEEP) or inspiratory pressure (Pi)*	≤ 20 cm H_2O
***Driving Pressure + PEEP**	**<23**

Most Bilevel devices can deliver a maximum pressure (Driving Pressure + PEEP) of 25 cmH_2O. For safety, given a potential increase of resistance in the bilevel circuit, we recommend that these devices are most appropriate for patients with settings on conventional ventilation as follows:

- *If patient on Pressure Control mode: check that Inspiratory Pressure (Pi) + PEEP is below 23 cmH_2O*
- *If patient on Volume Control mode: check that plateau pressure is below 23 cmH_2O*

TRANSITIONING FROM CONVENTIONAL VENTILATOR TO BILEVEL VENTILATOR

Bilevel devices provide positive pressure ventilation in a manner analogous to pressure control ventilation on traditional ventilators.

Calculate patient ideal body weight (IBW) from height and goal tidal volume (TV) of ***6 - 8 cc/kg with plateau pressure ≤ 30.***

Philips Respironics Device Settings:

MODE: ST (bi-level)

EPAP = PEEP

IPAP:

- If patient is on Pressure Control (AC/PC) mode:

  IPAP = PI + PEEP

- If patient is on Volume Control (VC/PC) mode:

  IPAP = plateau pressure (perform inspiratory pause maneuver)

Resp Rate: Match the patient's rate

Ti: 0.5-3 sec (see limits based on respiratory frequency; see chart (Table 2)

Rise Time: 1

Oxygen: 15 lpm via first port, add additional O_2 via second port if needed to achieve goal FiO_2 90-92%. Check PaO_2/SpO_2

Table 2: Ti settings based on Respiratory Rate (RR):

Respiratory Rate (bpm)	Max Ti = 30/RR
30	1
25	1.2
20	1.5
15	2.0
12	2.5

ResMed Device Settings:

MODE: ST (bilevel)

EPAP = PEEP

IPAP:

- If patient is on Pressure Control (AC/PC) mode:

  IPAP = PI + PEEP

- If patient is on Volume Control (VC/PC) mode:

  IPAP = plateau pressure (perform inspiratory pause maneuver)

Resp Rate: Match patient's rate

Ti Max: Based on respiratory frequency; see chart (Table 2)

Ti Min: Based on respiratory frequency; see chart (Table 2)

Rise Time: Min

Trigger: Low

Cycle: Low

Oxygen: 15 lpm via port—DO NOT exceed 15LPM of supplemental oxygen

If an FiO_2 > 60% is required, you must use a different bi-level device

Warning: With ResMed VPAP ST and AirCurve bi-levels, supplemental oxygen > 15 LPM in a circuit with a standard exhalation port can result in an unanticipated device shut-off and patient harm

Table 3: Ti settings based on Respiratory Rate (RR):

Respiratory Rate (bpm)	Ti Max = 30/RR	TiMin = ½ TiMax
30	1	0.5
25	1.2	0.6
20	1.5	0.8
15	2.0	1.0
12	2.5	1.3

Whenever a patient is started on a bilevel ventilator <u>or</u> if a change in IPAP or EPAP is made, VERIFY TV reading on bilevel device display or on gas sampling/flow monitor:

- TV > 6 – 8 cc/kg IBW → lower IPAP in 3-5 cm H_20 increments until at/near goal
- TV < 6 - 8 cc/kg IBW with unacceptable hypercapnia/respiratory acidosis:
    - If not already at device maximum IPAP (25 cm H_2O), increase IPAP in 3-5 cm H_2O increments until TV at goal
    - If IPAP at maximum of 25 cm H_2O, check ABG → if unacceptable degree of hypercapnia/respiratory acidosis, increase RR to maximum of 35 bpm
    - If IPAP at maximum of 25 cm H_2O, RR at maximum of 35 bpm, with severe respiratory acidosis, decrease EPAP by 3-5 cm H_2O (if oxygenation tolerated as measured)
        - NOTE: More advanced device support may be needed if unable to achieve adequate ventilation and oxygenation despite these adjustments.
- End-tidal CO_2 readings can be used as a surrogate indicator of changes in ventilation if tidal volume readings are not available
- Check FiO_2

OXYGEN and FIO2

The circuit is usually set up with supplemental oxygen flow at 15 lpm. A second oxygen port can be used to add additional oxygen if needed.

WARNING: the Resmed VPAP ST and AirCurve have a feature that will cause an unexpected shut-down of the device if the supplemental O2 flow exceeds the leak; this appears to the software as a "tube blocked" condition. DO NOT EXCEED 15 l/min of supplemental O2 if using these devices and the set pressure is above 10 cm H20.

- Check FiO_2 on gas sampling/flow monitor if possible at the start of therapy
- FiO_2 may drop slightly if IPAP or EPAP is increased without increasing oxygen flow rates (especially if using single source of O_2 at 15 lpm)
- Check for changes in SpO_2 and/or PaO_2 after increasing IPAP or EPAP
- **DO NOT increase O2 > 15 lpm if EPAP is ≥ 10 cmH_2O**

Comments on LEAK

- The current set up of the circuitry provides the necessary degree of leak needed to prevent CO_2 re-breathing (this value cannot be displayed); this leak is filtered
- When all tubing circuitry is connected and working properly, the ResMed VPAP-ST screen should read a LEAK of 0 as this display is NOT the total leak, but the leak in excess of that intended and filtered. Other bilevel devices display the total leak. On other bilevel devices, the leak displayed is the total leak.
    - If reading goes above 0 on the Resmed devices, or above 40 l/min on other devices, there may be an unexpected leak in the system (cuff leak, disconnected tubing etc). This condition can result in:
        - Loss of delivered pressure, unexplained drop in patient SpO_2, sudden change (up or down) in end-tidal CO_2, and drop in TV readings,
        - Exposure of healthcare providers to *unfiltered* leak
- If you see this, check circuit, including all connections, ETT cuff inflation