

Application of Airway Pressure Release Ventilation in Adults in Critical Care

Key Points

- This guideline is intended for use for adult patients with recruitable, acute restrictive lung disease such as:
 - Acute Respiratory Distress Syndrome (ARDS)
 - Alveolar haemorrhage
 - Pulmonary contusion
 - Pulmonary oedema
- This guideline may also be appropriate for lung dysfunction secondary to reduced thoracic compliance due to:
 - Obesity
 - Chest wall oedema
 - Increased intra-abdominal pressure
 - Spinal cord injury

Version: 2.0
Date Issued: 1 July 2024
Review Date: April 2027
Key words: APRV, ventilation, weaning

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Abbreviations

ACT	Airway clearance techniques
APRV	Airway Pressure Release Ventilation
ARDS	Acute Respiratory Distress Syndrome
CPAP	Continuous Positive Airway Pressure
CWV	Chest wall vibrations
FRC	Functional residual capacity
MHI	Manual hyperinflation
MI-E	Mechanical insufflation-exsufflation
PC-BIPAP	Pressure-control bi-phasic airway pressure
PEF	Peak expiratory flow
PEFR	Peak expiratory flow rate
RASS	Richmond Agitation and Sedation Scale
SPN-CPAP/PS	Spontaneous continuous positive airway pressure / pressure support
VHI	Ventilator hyperinflation
WOB	Work of breathing

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1. Definition of APRV

Airway Pressure Release Ventilation (APRV) is the application of Continuous Positive Airway Pressure (CPAP) to maintain spontaneous breathing with an optimal functional residual capacity (FRC) for alveolar capillary gas exchange with the addition of occasional pressure releases to augment carbon dioxide (CO₂) removal. The objective of APRV is to maintain a high mean airway pressure primarily to facilitate alveolar recruitment and thus oxygenation with the timed releases augmenting CO₂ clearance. Spontaneous breathing may occur at any time during the cycle enabling the patient to augment ventilation throughout the respiratory cycle (1) (2) (3).

2. Terminology

Pressure High (P _{high})	- the baseline airway pressure or 'CPAP' pressure - the higher of the two airway pressures
Pressure Low (P _{low})	- the airway pressure resulting from the pressure release or 'PEEP' level
Time High (T _{high})	- the length of time for which P_{high} is maintained
Time Low (T _{low})	- the actual duration of the airway pressure release - the absolute duration of T_{low} may vary from breath to breath if utilising the Exp Term and T_{lowmax} settings via the Auto-release function (only available on the Dräger Evita® Infinity® V500 & C500 ventilators)
T _{lowmax}	- maximum duration of the airway pressure release allowed by the ventilator before terminating the pressure release and cycling back up to P_{high} when Auto-Release
Peak Expiratory Flow rate (PEFR)	- PEFR is the fastest or 'peak' flow rate during expiration
Expiratory Term (Exp Term)*	- the percentage of the PEFR at which the ventilator terminates the pressure release or T_{low} and cycles back up to P_{high} - the expiratory flow rate is fastest (100% of PEFR) at the beginning of the release phase. The expiratory flow rate will decelerate as the release period continues. This should be set at 75% unless otherwise agreed with the Consultant.
Auto-Release*	- the function on the ventilator that allows you to select the Expiratory Termination & T_{lowmax} settings - This setting is found in 'Additional Settings'
P _{mean}	- Mean Airway Pressure

* This function is only available on the Dräger Evita® Infinity® V500 & C500 & V800 ventilators. It is not available on the Evita® XL model. (Please see Appendix 3 for how to use auto-release function & set Exp Term.)

3. Relative contraindications of APRV

- Obstructive lung disease in which the expiratory flow cannot decrease to 50% of the peak expiratory flow (PEF) in 1second. The decision to implement APRV in patients with obstructive lung disease should be made by an ICU Consultant
- Profound cardiovascular instability (particularly if secondary to untreated hypovolaemia)
- Recent pulmonary resection with staple lines or anastomosis (i.e., postoperative lobectomy and pneumonectomy)
- Severe bronchospasm
- Pulmonary hypertension with right ventricular decompensation (although a trial of APRV may be considered with close echocardiographic monitoring)
- Bronchopleural fistula
- Untreated pneumothorax
- Restrictive lung disease

4. Goals of APRV

- Increase (recruit) and maintain lung volume (2)
- Decrease work of breathing (WOB)
- Allow spontaneous breathing within 24 hours of application (2) (3)
This is an integral part of how APRV works & in order to gain the maximal benefits from this mode of ventilation it is essential that allowing a spontaneous respiratory drive is considered for all patients. Depending on the severity of their critical illness there may be a group of patients for whom this is not appropriate, but this should be a consultant-led decision. For those patients who are not able to have a spontaneous respiratory rate it may be more difficult to control PaCO₂ levels.
- Minimise number of airway pressure releases required and supplement ventilation with spontaneous breathing (3)
- Limit alveolar de-recruitment by limiting duration of T_{low} by setting an expiratory termination of 75% of PEF (should be 75% unless altered by physio/ consultant)
- Aim to remain at P_{high} for 90% of duration of respiratory cycle (2)
The T_{high} should be 10x the duration of actual T_{low}, ensuring that 90% of the respiratory cycle is spent at P_{high} e.g: If T_{high} is set at 5.5 seconds, the actual time spent at T_{low} should not be more than 0.55 seconds. To ensure this is the case the expiratory termination & T_{lowmax} or T_{low} should be set correctly (please see section 5).

Any time adjustments are made to the ventilator settings it is important to assess the impact that these may have on the relationship between T_{high} & T_{low} & on P_{mean} & subsequent alveolar recruitment.

Please note that different models of ventilator are used across the trust.
 The Frimley Park site uses the Dräger Evita® Infinity® V500
 The Wexham Park site uses the Dräger Evita® Infinity® C500 & the Evita XL.
 Both sites have the Dräger Evita® Infinity® V800
 Please refer to the set up guidance for the correct ventilator model required

5. Initial Set-up

5i) Initial set up for Dräger Evita® Infinity® V800, V500 (FPH) & C500 ventilators (WPH)

- ATC - Should always be set
- P_{high} - If newly intubated set desired plateau pressure, between 20-30 cmH₂O (4)
 - If transitioning from conventional pressure-control ventilation should at least equal the previous peak pressure (4)
 - If transitioning from conventional volume-controlled ventilation should at least equal the plateau pressure (4)

N.B: Patients with decreased thoraco-abdominal compliance or morbid obesity may initially need up to 35cm H₂O, but this should be reduced as soon as the patient is adequately recruited. The decision to use pressures >30 cmH₂O must always be consultant-led.

- P_{low} - always set at 0 cmH₂O (5)
- T_{high} - initial range is 4.0 to 6.0 seconds
 - consider setting at 5.5 - 6.0 seconds if haemodynamically stable
 - consider setting at 4.0 - 4.5 seconds if abnormal pH and PaCO₂ &/or haemodynamic instability
- T_{lowmax} - maximum of 0.8 seconds (5) (6)
 - the absolute T_{low} will be dictated by the Exp Term
- Exp term - Expiratory Termination Point should be set at 75% of PEFR (6) (please see appendix 4 for how to use auto-release function & set Exp Term)

Please consider the use of a ventilator view that includes sufficient information about both the mandatory ventilation & the patient's spontaneous respiratory effort. It is recommended to regularly review both the spontaneous & mandatory rates & tidal volumes as well as the P_{mean} & the percentage of minute ventilation that is contributed through spontaneous ventilation (%MV_{spont}).

On the Frimley site this information is pre-programmed as 'View 2'.

On the Wexham Park site please consider changing the ventilator view to display these parameters.

5ii) Initial set up for Dräger Evita® XL ventilator (WPH only)

- ATC - Should always be set
- P_{high} - If newly intubated set desired plateau pressure, between 20-30 cmH₂O (4)
- If transitioning from conventional pressure-control ventilation should at least equal the previous peak pressure (4)
- If transitioning from conventional volume-controlled ventilation should at least equal the plateau pressure (4)

N.B: Patients with decreased thoraco-abdominal compliance or morbid obesity may initially need up to 35cm H₂O, but this should be reduced as soon as the patient is adequately recruited. The decision to use pressures >30 cmH₂O must always be consultant-led.

- P_{low} - always set at 0 cmH₂O (5)
- T_{high} - Initial range is 4.0 to 6.0 seconds
- consider setting at 5.5 - 6.0 seconds if haemodynamically stable
- consider setting at 4.0 - 4.5 seconds if abnormal pH and PaCO₂ &/or haemodynamic instability
- T_{low} - range of 0.2 - 0.8 seconds
- the correct T_{low} should be such that the airway pressure release terminates at 75% of the patient's PEFR (please see appendix 3 for how to calculate desired T_{low})
- Please note that the T_{low} will need to be regularly recalculated as the time it takes to decelerate to 75% of the PEFR will vary over time (5) (6)

Please consider the use of a ventilator view that includes sufficient information about both the mandatory ventilation & the patient's spontaneous respiratory effort. It is recommended to regularly review both the spontaneous & mandatory rates & tidal volumes as well as the P_{mean} & the percentage of minute ventilation that is contributed through spontaneous ventilation (%MV_{spont}).

On the Frimley site this information is pre-programmed as 'View 2'.

On the Wexham Park site please consider changing the ventilator view to display these parameters.

5iii) Spontaneous Breathing

- Aim to achieve a spontaneous respiratory rate within 24hrs of application of APRV (3) unless otherwise advised by the Consultant
 - Aim for a RASS (Richmond Agitation & Sedation Score) of -1 to 0 unless otherwise advised by the Consultant

The addition of a spontaneous respiratory rate allows for a greater minute ventilation to help increase bulk ventilation whilst giving time for alveolar recruitment. However, there are a group of patients in whom it may be more appropriate to keep deeply sedated. This decision should be consultant-led.

Figure 1.

Diagram of ventilator pressure waveform during APRV:

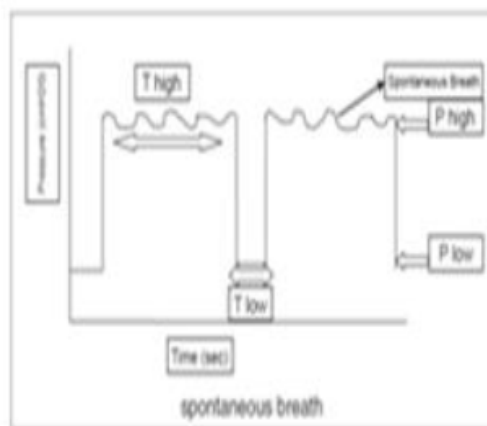
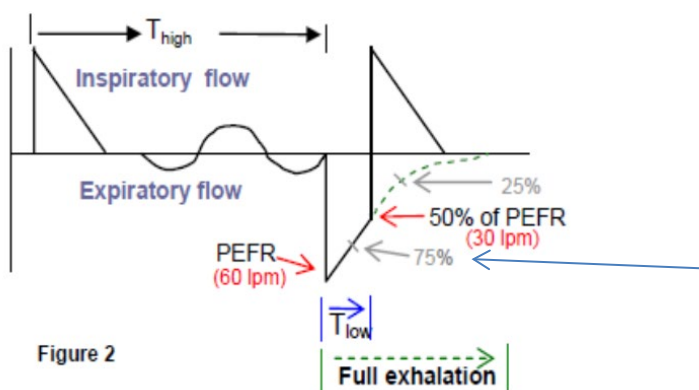


Figure 2.

Diagram demonstrating the expiratory flow waveform during a time-cycled airway pressure release phase of APRV:



V500/C500/V800 models: Once the Exp Term is set at 75%, this is the point at which the exhaled breath will be terminated.

Evita XL model: The T_{low} needs to be calculated to terminate the airway

6. Strategies to improve oxygenation

The general premise when using APRV to improve oxygenation is to maintain or increase the mean airway pressure (P_{mean}), thus facilitating improved alveolar recruitment and increasing functional surface area for alveolar gas exchange. (1) (2)

- Limit potential alveolar de-recruitment by minimising circuit disconnections and ensuring the airway pressure release terminates at 75% of PEFV
- Increase P_{high} in 1-2 cmH₂O increments (may increase up to 35cmH₂O only on discussion with consultant)
- **Or** increase P_{high} and T_{high} simultaneously (T_{high} can be increased in 0.5 sec increments up to 8 sec). This will have a greater impact on P_{mean} & therefore alveolar recruitment.

Be aware of the impact on minute ventilation on increasing the T_{high} , e.g., if T_{high} is already set at six seconds & the patient is not spontaneously breathing, increasing the T_{high} further may reduce the minute ventilation sufficiently to adversely affect CO₂ clearance.

Please remember that it may take time for alveolar recruitment to occur before an improvement in gas exchange/ ventilation is observed.

7. Strategies to improve ventilation

During APRV a large proportion of CO₂ clearance occurs via diffusion, as opposed to the reliance of conventional ventilatory modes of bulk ventilation to clear CO₂ from the lungs. Therefore, strategies to improve alveolar recruitment and gas exchange may ultimately improve CO₂ clearance when utilising APRV. Both time-cycled airway pressure releases and spontaneous breathing contribute to ventilation and thus CO₂ clearance during APRV.

- Assess for over-sedation (3)
 - Using the Richmond Agitation and Sedation Scale (RASS) – aim for a RASS of -1 to 0 unless otherwise advised by the Consultant
 - aim to facilitate spontaneous breathing to contribute to the minute ventilation
- Adjust T_{lowmax}/ T_{low}
 - ONLY if set incorrectly (please see sections 4 & 5 for more details)

7i) 1st line strategy

- Increase P_{high} in 1-2 cmH₂O increments
 - Increases surface area
- Increase T_{high} in 0.5 sec increments up to 6 sec (in some circumstances T_{high} can be increased to 8 sec, on discussion with Consultant)
 - Increases amount of time for alveolar ventilation
 - Increases P_{mean} by both increasing the pressure & the time held at the higher pressure

7ii) 2nd Line strategy

- Decrease T_{high} in 0.5 sec increments
 - Increases minute ventilation by increasing the number of time-cycled airway pressure releases per minute
 - Metabolic load maybe too high

Cautions: Reducing the T_{high} in an effort to improve minute ventilation and allow for more time-cycled airway pressure releases per minute, will reduce the P_{mean} at the risk of causing alveolar de-recruitment and potential impairment in gas exchange. PaCO₂ may in fact increase as a result. If the reduction in T_{high} causes the T_{low} to exceed 10% of T_{high}, there is greater risk of causing alveolar de-recruitment.

N.B: If the P_{high} is increased at the same time as decreasing the T_{high} there may be a less significant impact on the P_{mean} & therefore a reduced risk of alveolar decruitment.

Weaning from APRV

If APRV has been deemed to be an appropriate & effective mode of ventilation for the patient then they should remain on this mode until they are weaned as discussed in this section (3). Prior to weaning from APRV the initial lung insult that led to the instigation of APRV should have been resolved. Weaning from APRV has been described as a 'drop and stretch' approach, with a gradual reduction in P_{mean} whilst increasing the contribution of spontaneous breathing to the total minute ventilation. In order to wean successfully from APRV the patient needs to have both an adequate respiratory drive and the ability to take spontaneous breaths of sufficient volume to contribute effectively to ventilation and CO_2 clearance.

Parameters to be achieved prior to commencement of weaning (unless altered parameters given by consultant):

- $\text{FiO}_2 \leq 0.40$
- pH 7.30 – 7.50
- $\text{PaO}_2 \geq 8 \text{ kPa}$
- $\text{SpO}_2 \geq 90$
- Minimal inotropic requirements
 - $\text{SBP} > 90\text{mmHg}$
 - $\text{P} 0.1 \leq 3$
- Ensure adequate respiratory drive by assessing patient's spontaneous respiratory rate and spontaneous tidal volumes
- Decrease P_{high} by $2\text{cmH}_2\text{O}$ until reach $20\text{cmH}_2\text{O}$ with stable ABG & FiO_2 requirements
- If at this point spontaneous ventilation contributes to $\geq 40\%$ MV can commence 'drop & stretch' weaning:
 - Decrease P_{high} by $1-2 \text{ cmH}_2\text{O}$ and simultaneously increase T_{high} by up to 0.5 to 2 seconds
- Ensure oxygenation and ventilation are adequate at each step and continue to gradually reduce mean airway pressure in this step-wise fashion
- If either oxygenation or ventilation deteriorate remain at the current step or return to the P_{high} and T_{high} of the previous step/s
- Investigate cause for weaning failure and resume once this has been resolved
- Once P_{high} is $\leq 16 \text{ cmH}_2\text{O}$ and $T_{\text{high}} \geq 12-15\text{seconds}$ convert to SPN-CPAP, matching the PEEP to the current P_{mean} (no pressure support should be required)
- Consider extubation from SPN-CPAP mode once PEEP has been reduced to $5-10 \text{ cmH}_2\text{O}$

Weaning failure criteria (failure if 2 or more are sustained)

- Clinically dyspneic, diaphoretic, agitated
- HR $\neq$ $\pm 20\%$ change from baseline
- $\text{SpO}_2 \leq 90\%$ (or less than targeted saturations) with $\text{FiO}_2 \geq 0.40$
- $\text{RR} \geq 30\text{bpm}$ (unless neurologically driven)
- $\text{Vt} \leq 4\text{mls/kg/IPBW}$
- $\text{RSBI} > 80$ or a 300% increase in trend
- $\text{NIF} < 20\text{cmH}_2\text{O}$
- $\text{P}0.1 > 3$ or significant increase post-weaning

8. Troubleshooting

- Drop in SpO₂ on commencement of APRV – consider volume depletion. If SpO₂ responds to fluid resus/ leg raise then put back onto conventional ventilation until adequately filled to tolerate APRV
- Raised CO₂ – usually allow permissive hypercapnia as long as within targeted pH range (as set by Consultant)
 - Usually less common if APRV is used early
 - follow advice in guidance Section 7
- Haemodynamic compromise – again consider fluid status

9. Implications for physiotherapy

Airway clearance techniques (ACT) are a key area of critical care physiotherapy & have been demonstrated to increase sputum yield for mechanically ventilated patients. Key components of ACT are manual techniques such as chest wall vibrations (CWV) and percussion & hyperinflation techniques such as manual hyperinflation (MHI) & ventilator hyperinflation (VHI). A more novel adjunct is the use of mechanical insufflation-exsufflation (MI-E) or CoughAssist device via an endo-tracheal tube for patients who are receiving invasive mechanical ventilation. The utilisation of APRV may affect the clinically reasoned ACT delivered by critical care physiotherapists.

N.B: It is outside the scope of these guidelines to discuss the indications/ precautions/ contraindications for the various ACT discussed. Please refer to the relevant physiotherapy guidelines for more details.

Manual Techniques

The use of CWV requires appropriate initiation & timing to deliver the oscillatory force to the patient's chest wall at the commencement of expiration. CWV may not be optimally effective during APRV where there is no spontaneous respiration. The release phases during APRV are usually of too short a duration to provide effective CWV. If a patient has a consistent spontaneous respiratory rate then CWV could be applied during these breaths. If not & manual techniques are indicated then percussion may be an alternative treatment option.

Hyperinflation Techniques

For patients dependent on the mean airway pressure of APRV disconnecting from the ventilator to perform MHI may be detrimental & lead to alveolar decruitment. In this patient group VHI may be more appropriate as there is no need to disconnect from the ventilator. In order to perform VHI however, the patient would have to be placed on either SPN-CPAP/PS or PC-BIPAP (depending on the patient's spontaneous respiratory effort) for the duration of treatment. This may not be suitable for patients who are dependent on a high mean airway pressure but may be more appropriate for patients who are tolerating a wean from APRV. Advice should be sought from the Consultant prior to commencing a trial of MHI or VHI for patients on APRV.

MI-E

The use of MI-E via either a tracheostomy or endo-tracheal tube requires the patient to be temporarily disconnected from the ventilator & so again may be detrimental & lead to alveolar decruitment in patients reliant on high mean airway pressures. Advice should be sought from the Consultant prior to a trial of MI-E for patients on APRV.

As in some instances the utilisation of ACT may be limited appropriate use of humidification & mucolytics is especially important for patients receiving APRV.

References

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Appendix 1: Application of APRV

Inclusion Criteria

- ARDS
- Alveolar haemorrhage
- Pulmonary contusion
- Pulmonary oedema

May also be appropriate for lung dysfunction secondary to reduced thoracic compliance due to:

- Obesity
- Chest wall oedema
- Increased intra-abdominal pressure

Initiation of APRV

Initial set up for Dräger Evita® Infinity® V800, V500 (FPH) & C500 ventilators (WPH)

P_{high}

- Usual range: 20-30 cmH₂O
- Use previous plateau pressure if in volume-controlled mode
- Use previous peak pressure if in pressure-controlled mode

N.B. Patients with significant decreased compliance/ morbid obesity may require pressures up to 35 cmH₂O but this must be a consultant-led decision

P_{low}

- Always set at 0 cmH₂O

T_{high}

- Usual range: 4.0-6.0 seconds
- Consider 5.5-6.0 seconds if haemodynamically stable
- Consider 4 seconds if abnormal pH & PaCO₂ +/- haemodynamic instability

T_{lowmax}

- Maximum of 0.8 seconds
- Ensure adequate time to allow Exp Term to function (see appendix 4)

Exp Term

- Set at 75% of PEFR

Initial set up for Dräger Evita® XL ventilator (WPH only)

P_{high}

- Usual range: 20-30 cmH₂O
- Use previous plateau pressure if in volume-controlled mode
- Use previous peak pressure if in pressure-controlled mode

N.B. Patients with significant decreased compliance/ morbid obesity may require pressures up to 35 cmH₂O but this must be a consultant-led decision

P_{low}

- Always set at 0 cmH₂O

T_{high}

- Usual range: 4.0-6.0 seconds
- Consider 5.5-6.0 seconds if haemodynamically stable
- Consider 4 seconds if abnormal pH & PaCO₂ +/- haemodynamic instability

T_{low}

- Maximum of 0.8 seconds
- Calculate required duration to allow release phase to terminate at 75% of PEFR (see Appendix 3)

Titration of APRV

Hypoxemia

- Ensure airway pressure release terminates at 75% of PEFR
- Increase P_{high} in 1-2cmH₂O increments
- **OR** increase P_{high} & T_{high} simultaneously (T_{high} can be increased in 0.5sec increments up to 8 sec)

Hypercapnia

- Assess for oversedation
 - RASS of -1 to 0
- Adjust $T_{\text{low}}/T_{\text{lowmax}}$
 - ONLY if set incorrectly

i) 1st line strategy

- Increase P_{high} in 1-2 cmH₂O increments
- Increase T_{high} in 0.5 sec increments up to 6 sec (in some circumstances T_{high} can be increased to 8 sec, on discussion with Consultant)

ii) 2nd Line strategy

- Increase P_{high} in 1-2 cmH₂O increments
- Decrease T_{high} in 0.5 sec increments to 4 sec

Appendix 2: Weaning of APRV

Parameters to be achieved prior to commencement of weaning (unless altered parameters given by consultant):

- $\text{FiO}_2 \leq 0.40$
- pH 7.30 – 7.50
- $\text{PaO}_2 \geq 8 \text{ kPa}$
- $\text{SpO}_2 \geq 90$
- Minimal inotropic requirements
- SBP > 90mmHg
- $\text{P 0.1} \leq 3$

Weaning failure criteria (failure if 2 or more are sustained)

- Clinically dyspneic, diaphoretic, agitated
- HR $\pm$ 20% change from baseline
- $\text{SpO}_2 \leq 90\%$ (or less than targeted saturations) with $\text{FiO}_2 \geq 0.40$
- RR $\geq 30\text{bpm}$ (unless neurologically driven)
- $\text{Vt} \leq 4\text{mls/kg/IPBW}$
- RSBI > 80 or a 300% increase in trend
- NIF < 20cmH₂O
- $\text{P0.1} > 3$ or significant increase post-weaning

Weaning Algorithm

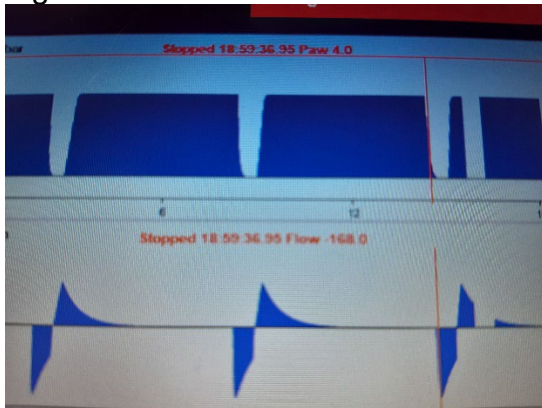
- Ensure adequate respiratory drive by assessing the patient's spontaneous respiratory rate & spontaneous tidal volumes
 - Ensure FiO_2 reduced to at least 0.40
1. Decrease P_{high} by 2cmH₂O until reach 20cmH₂O with stable ABG & FiO_2 requirements
 2. If at this point spontaneous ventilation contributes to $\geq 40\%$ MV can commence 'drop & stretch' weaning:
 - Decrease P_{high} by 1-2 cmH₂O and simultaneously increase T_{high} by up to 0.5 to 2 seconds
 3. Ensure oxygenation and ventilation are adequate at each step and continue to gradually reduce mean airway pressure in this step-wise fashion
 4. If either oxygenation or ventilation deteriorate remain at the current step or return to the P_{high} and T_{high} of the previous step/s & investigate cause for weaning failure and resume once this has been resolved
 5. Once P_{high} is $\leq 16 \text{ cmH}_2\text{O}$ and $\text{T}_{\text{high}} \geq 12\text{-}15\text{seconds}$ convert to SPN-CPAP, matching the PEEP to the current P_{mean} (no pressure support should be required)
 6. Consider extubation from SPN-CPAP mode once PEEP has been reduced to 5-10 cmH₂O

Appendix 3: How to manually calculate the airway pressure releases & T_{low}

The time it takes to allow the expiratory flow to decelerate to 75% of the PEFR can be calculated in the following way:

1. Press the 'freeze waveforms' button on the ventilator screen
2. Calculate when the airway pressure release starts (see Fig 1) by using the rotary knob to scroll along the ventilator screen until the measurement line is at the point at which pressure cycles down from P_{high} to P_{low} . This should line up with the peak of the expiratory flow waveform. You can see what the actual PEFR is as shown below:

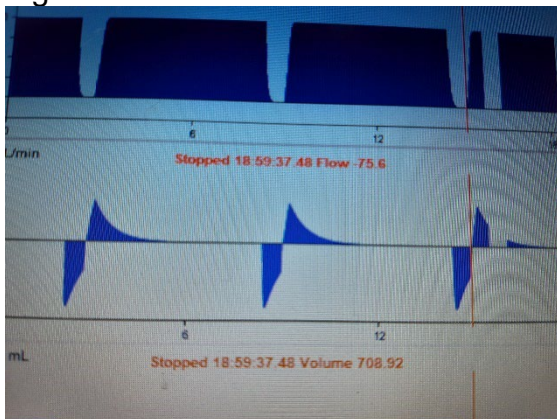
Fig 1:



Airway pressure release commenced at 18:59:36.95 with a PEFR of 168 l/min

3. Use the rotatory knob to scroll along the expiratory flow waveform until you reach the end of the airway pressure release phase. The expiratory flow will suddenly decelerate sharply back to an inspiratory phase as the pressure cycles back up from P_{low} to P_{high} . Calculate how long it took to reach the end of the airway pressure release, as shown below:

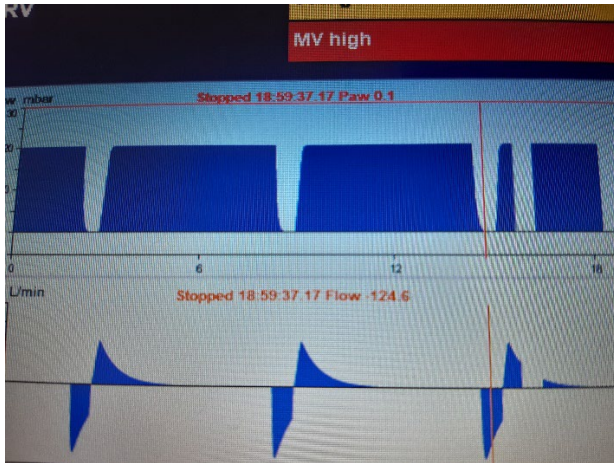
Fig 2:



Airway pressure release commenced at 18:59:36.95 with a PEFR of 168 l/min & terminated at 18:59:37.48 at an expiratory flow of 75.6 l/min. This means that the airway pressure release was 0.53secs long & terminated at 45% of the PEFR. In this example the T_{low} was set too long & there is a risk of derecruitment on the airway pressure releases.

4. Calculate 75% of the PEFR (in this example it would be $168 \div 100 \times 75 = 126$).
5. Using the rotatory knob scroll along the expiratory waveform until you reach as close to 75% of the PEFR as possible (126 l/min in this example)
6. Calculate the time taken to decelerate to 75% of the PEFR as shown below:

Fig 3:



75% of the PEFR was calculated to be 126 l/min. The expiratory flow decelerated to 124.6 l/min by a time of 18:59:37.17, meaning it took 0.23secs to do so.

7. The T_{low} should be set at the time it takes to decelerate to 75% of the PEFR – in this example that would be 0.23sec
8. Consider what your T_{high} setting is – remember the aim to be at P_{high} for approximately 90% of the respiratory cycle. If the T_{low} is >10% of the T_{high} , consider increasing the T_{high} if necessary. You would not generally reduce the T_{low} in this instance as that would mean the T_{low} would terminate the airway pressure release before the flow had decelerated to 75%. This could lead to inadequate ventilation.

Please note that if using without the Auto-Release function the required T_{low} should be recalculated at least once a shift. It should also be recalculated after any significant intervention that may alter the resistance of the airways, e.g., after bronchodilators, chest physio or multiple deep suction via ETT or tracheostomy. If a patient appears obstructed, e.g., due to bronchospasm, then please recalculate & adjust the T_{low} accordingly.

If the T_{low} is incorrectly set too long, then the airway pressure release will continue past the point at which the expiratory flow has reached 75% of the PEFR. This risks decruitment during the airway pressure release phase. In this situation overtime you may see worsening oxygenation & potentially even increased CO_2 retention.

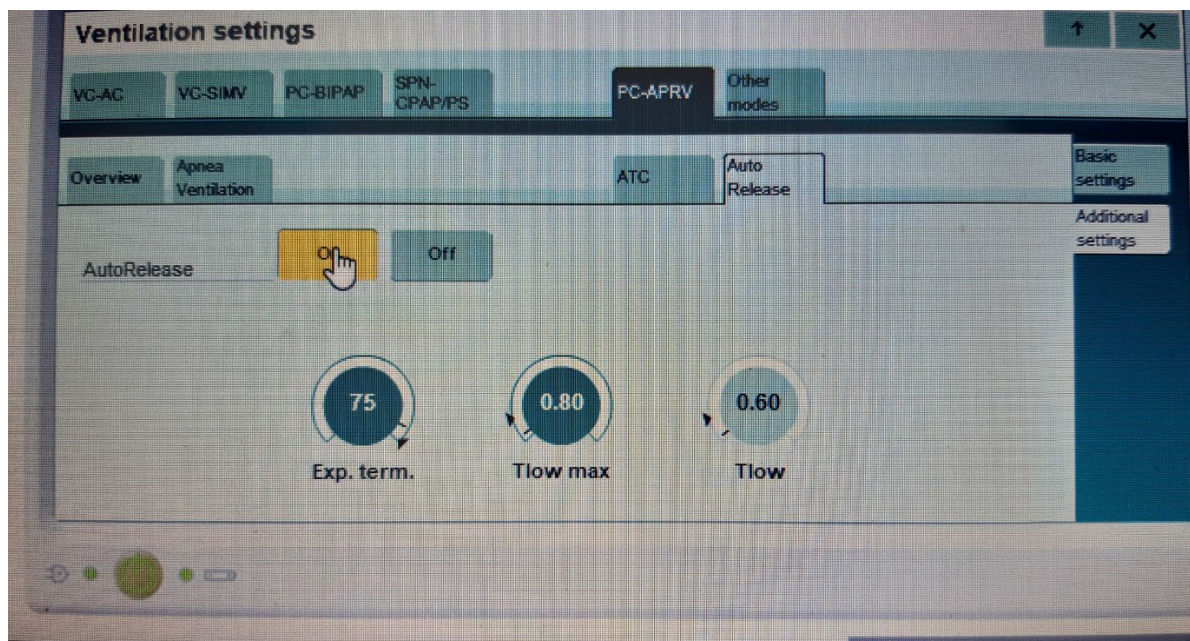
If the T_{low} is incorrectly set too short then it will cause the airway pressure release to terminate before the expiratory flow has decelerated to 75% of the PEFR. This means that a smaller volume will be released & overtime this will reduce the minute ventilation & can lead to inadequate ventilation & CO_2 retention.

Appendix 4: How to set Auto-Release function on the Dräger Evita® Infinity® V800, V500 (FPH) & C500 ventilators (WPH) only

The Dräger Evita® Infinity® V800 (both sites), V500 (FPH) & C500 (WPH) ventilators have an additional setting for use with APRV. This is the Auto-Release function. This function allows you to set the desired point at which the ventilator will terminate the airway pressure release, calculated on a breath-by-breath basis. It requires you to decide upon both a flow & time setting. The time setting is the T_{lowmax} , the maximum time the ventilator will maintain the P_{low} before cycling back up to the P_{high} set. The flow setting is the Exp Term, or Expiratory Termination Point, the percentage of the PEFR at which the ventilator terminates the airway pressure release & cycles back up to P_{high} .

In order to set the Auto-Release function perform the following steps:

1. Calculate the time it takes the expiratory flow to decelerate to 75% of the PEFR as described in appendix 3
2. Go to ventilation mode
3. Go to 'Additional settings'
4. Choose 'Auto-release'
5. Set Exp Term at 75 (unless otherwise advised by consultant)
6. Set T_{lowmax} at desired time – the minimum setting would be the time calculated in step 1
- it may be prudent to set T_{lowmax} longer than this to allow for changes in expiratory flow & the subsequent time it takes to achieve the set Exp Term
7. Press 'on' when you are happy with your settings
8. Confirm with rotary knob



9. Reconfirm that the airway pressure release is terminated at 75% of the PEFR (see appendix 3)

Please note that whichever occurs first; reaching the time set as T_{lowmax} or decelerating to the specified percentage of the PEFR set as the Exp Term will terminate the airway pressure release. If the T_{lowmax} is incorrectly set too short, then it will cause the airway pressure release to terminate before the expiratory flow has decelerated to the percentage of PEFR set as the

Expiratory Termination point. This means that a smaller volume will be released & overtime this will reduce the minute ventilation & can lead to inadequate ventilation & CO₂ retention.

As there are many variables affecting expiratory flow it is recommended to either set the T_{lowmax} towards the end of the guidance range of 0.2 – 0.8seconds or to regularly reassess the airway pressure release phases as described previously.

Full version control record

Version:	2.0
Guidelines Lead(s):	Georgina Linstead, Advanced Physiotherapy Practitioner in Critical Care, Frimley Health NHS Foundation Trust Dr Elaine Hipwell, Consultant Intensivist, Frimley Park Hospital, Frimley Health NHS Foundation Trust
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Library check completed:	25/04/2024
Ratified at:	Critical Care Clinical Governance, 25 April 2024
Date Issued:	1 July 2024
Review Date:	April 2027
Pharmaceutical dosing advice and formulary compliance checked by:	N/A
Key words:	APRV, ventilation, weaning

This guideline has been registered with the Trust. However, clinical guidelines are guidelines only. The interpretation and application of clinical guidelines will remain the responsibility of the individual clinician. If in doubt, contact a senior colleague or expert. Caution is advised when using guidelines after the review date.

This guideline is for use in Frimley Health NHS Foundation Trust hospitals only. Any use outside this location will not be supported by the Trust and will be at the risk of the individual using it.

Version History

Version	Date	Guideline Lead(s)	Status	Comment
1.0	July 2020	Georgina Linstead & Dr Elaine Hipwell	Final	
2.0	April 2024	Georgina Linstead & Dr Hipwell	Final	

Related Documents

None