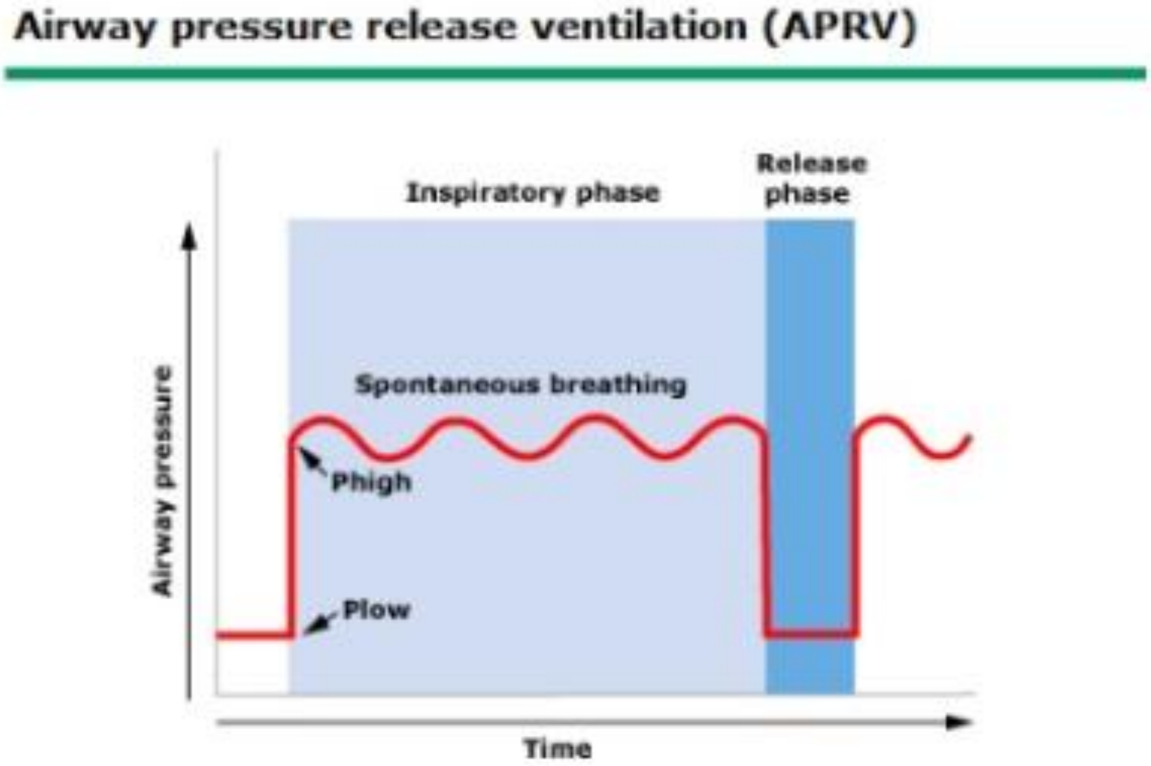
Understanding Airway Pressure Release Ventilation (APRV)



A Learning Resource for ICU Nursing Staff

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Definition

- Airway pressure release ventilation (APRV) uses patient or machine triggered, pressure targeted, time-cycled breaths and permits superimposed spontaneous breaths
- APRV switches automatically and regularly between the two operator selected levels of CPAP (p-high and p-low/PEEP)
- The unique feature of APRV is that it usually employs long inflation periods (i.e. several seconds) and short deflation periods (i.e. several seconds)
- This creates an ‘inverse ratio’ like support pattern with spontaneous breaths thereby occurring during the inflation period

Theory

- By lengthening inflation periods, additional lung recruitment can occur without adding additional expiratory pressure (PEEP) or tidal volume
- Mean airway pressure can thus be increased without an increase in the end inflation plateau pressure
- The superimposed spontaneous breaths may also provide even more ventilation distribution as well as augment cardiac filling

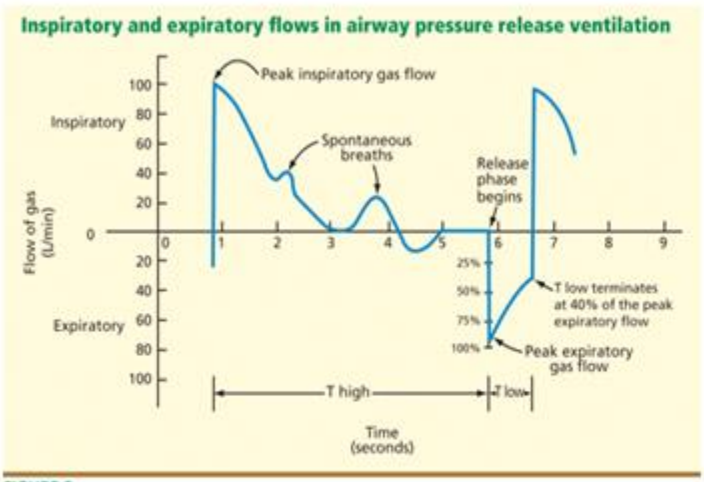
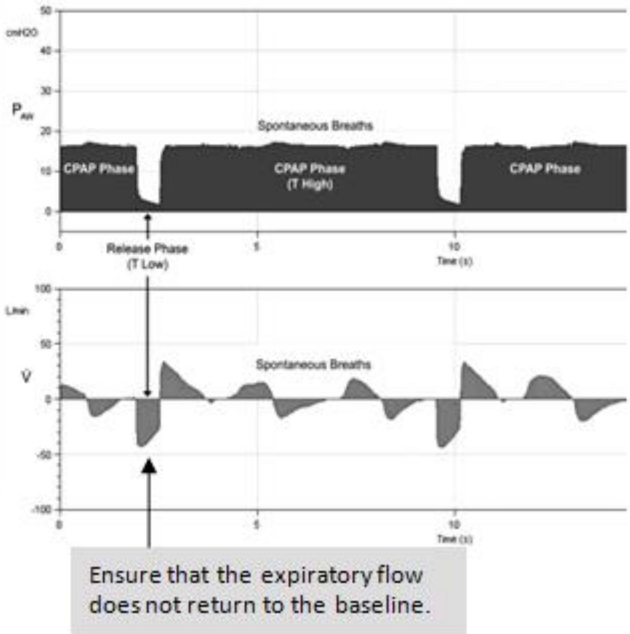


FIGURE 3



Caution - paralysing agents should be avoided in APRV as the patient should be allowed to breathe spontaneously

Responding to the demands of critical illness

Spontaneous breathing during APRV allows greater flexibility to the dynamic and rapidly changing metabolic demands of critical illness. When used as a preventive lung recruitment measure to maintain lung aeration, unassisted spontaneous breathing may reduce the need for reactive recruitment maneouvres. Also, the cardiopulmonary benefits of unassisted spontaneous breathing may reduce the negative physiologic effects of mechanical breaths on the circulation. In contrast, lack of spontaneous breathing may contribute to worsening respiratory dysfunction by increasing the risk of atelectasis and pulmonary infections. Complications of mechanical ventilation increase over time, and successful extubation depends on spontaneous breathing

How APRV maintains lung recruitment and preserves spontaneous breathing

In respiratory failure, the lungs become oedematous and heavy, causing alveolar collapse (atelectasis) and oppose the patient's effort to breathe efficiently. Typically, critically ill patients lack the strength to expand the lungs against these opposing forces without developing increased work of breathing

Air remaining in the lungs after exhalation is called end-expiratory lung volume (EELV). In adult males, normal EELV measures approximately 3litres. As atelectasis progresses, EELV may decrease by as much as one-third. As the weight of the heart, lungs, and abdominal contents causes additional compression, EELV decreases further. The resulting lung volume loss forces the lungs to expand from a lower EELV, causing excessive elastic work of breathing

With traditional modes of ventilation, such as synchronized intermittent mandatory ventilation (SIMV), the expiratory phase accounts for most of the ventilator time cycle. SIMV permits spontaneous breaths between set mandatory breaths at the positive end-expiratory pressure (PEEP) level. During the expiratory phase, PEEP is used to prevent alveolar collapse and maintain EELV. However, the PEEP level may be too low to overcome the reduced EELV and increased elastic work of breathing. As a result, the patient may require increased mandatory support from the ventilator, possibly limiting or eliminating spontaneous breathing

With APRV, on the other hand, most of the time cycle is spent at the upper CPAP level above EELV. Because APRV uses a brief release phase, the extended CPAP phase (90% and above) limits shear forces from cyclic opening and closing; this is crucial because shear forces may lead to stress failure of the lung. Thus, APRV improves dead space and shunt, resulting in less frequent and extreme changes between lung volumes than traditional ventilation. These effects decrease the elastic work of breathing and help preserve spontaneous breathing

Reduced sedation requirements

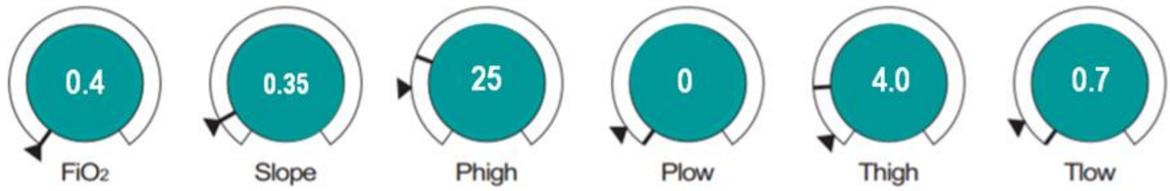
Preset ventilator settings that force the patient to breathe at a particular frequency and flow rate for a defined time at a clinician-prescribed tidal volume cause the patient's breathing to become out of synch with the ventilator. This asynchrony decreases patient comfort and may necessitate increased sedation or even paralytic agents. APRV reduces asynchrony by permitting the patient to breathe spontaneously at any time during the respiratory cycle. Because spontaneous breathing is allowed, patients can often remain quite comfortable during APRV and sedation requirements may be reduced. However, the long periods of high inflation pressures and the rapid deflation/inflation events can lead to some discomfort and sedation/analgesia is often needed – but a reduction in sedation requirements may still be observed

Airway Pressure Release Ventilation – Basic Settings Explained		
Parameter	**Initiate settings**	**Parameters and functions explained**
O2	**60**	Lowest setting is 21% equivalent to room air. Oxygenation of blood can be improved by increasing FiO2, increasing PEEP (intrinsic PEEP in APRV) or prolonging the inspiration time.
P-high	**25**	P-high is the inflation pressure. Set p-high to desired or target plateau pressure (20 to 30cmH20) and increase in 2 to 4 cm H2O increments to maintain pressure ideally ≤ 30. However, higher inflation pressures may be needed (up to 40cmH2O). Patients can breathe spontaneously at this level at any time.
P-low	**0**	P-low is the deflation pressure (or PEEP). **Ideally, p-low should be set to zero.** The short release time (T PEEP) allows a rapid flow of air out of the patient's lungs, similar to an 'exhalation'. This release of volume carries out CO2, thus enhancing ventilation. Setting the p-low above zero creates added resistance creating increased turbulent expiratory airflow.
T-high	**4.0**	T-high is the inflation *time*. Initial t-high setting: usually set 4-6 seconds. A minimum of 4 seconds is recommended in adults. The rationale for this is that it allows sustained alveolar recruitment. T-high is adjusted as long as possible providing the necessary minute ventilation. The patient's breathing throughout the ventilatory cycle adds to the total minute ventilation. **It is not recommended that the t-high is set less than 4.0 seconds,** i.e. to have no more than 12 releases per minute as shortening t-high may adversely affect mean airway pressure.
T-low	**0.7**	T-low is the deflation *time*. Initial t-low setting: usually set 0.4-1.0 seconds (often 0.7 seconds) and is determined by analysis of the expiratory gas flow curve. Generally, the t-low can be as short as 0.3 seconds (closer to 75% of the PEFR) in restrictive diseases (ARDS) and as long as 1.5 (closer to 50% of the PEFR) in obstructive states (COPD). Titrate t-low to obtain a **'peak expiratory flow rate termination point' at 50-75% of the measured 'peak expiratory flow'**. The rationale for this is that it maintains expiratory lung volume & prevents alveolar closure during the release phase. T-low **cannot be set too long** as this would interfere with oxygenation and recruited lung units might collapse.
Ramp	**0.35**	Rise time: determines the speed at which the set pressure can be achieved. Default setting is 0.2 seconds. Patients with stiff lungs e.g. brittle asthmatics/ARDS may benefit from a slightly slower rise time. A setting of 0.35 seconds is appropriate.
Trigger	**2.0**	2 litres is always set, irrespective of the patient's readiness to wean. Reducing the trigger setting makes it easier for the patient to trigger a spontaneous supported breath. Do **NOT** lower the setting < 2 litres/minute as auto-cycling may occur.

Use the following settings to IMPROVE OXYGENATION using APRV mode	
Titrate the t-low setting	Assess the peak expiration termination point: if it is < 50% of the measured peak expiratory flow, decrease t-low to obtain termination point up to 75% of the peak expiratory flow. This may help to maximise end expiratory lung volume. Shortening the t-low setting should increase auto PEEP and increase mean airway pressure and oxygenation. However, it may also reduce tidal volume and affect PaCO2.
Increase the p-high setting	Increase in 2 to 4 cm H2O increments, while assessing the patient's haemodynamic status. This setting may be increased up to 30cm H2O If extra-compliance is low, it may be necessary to increase this setting > 30 cm H2O (up to 40cmH2O may be needed) **Do not wean p-high until FiO2 < 60% and oxygenation is stable for at least 2 hours** Decrease p-high only by 2cm H2O at time
Increase the t-high AND the p-high at the same time	Lengthen t-high by 1 to 2 seconds with p-high titrations This may help to increase gas mixing and recruits alveoli with longer time constants Observe haemodynamics when titrating – poor haemodynamic response may warrant assessment of vascular volume and cardiac output

Use the following interventions to REDUCE THE PACO2 using APRV mode	
Assess sedation and spontaneous breathing	Titrate sedation to allow for spontaneous ventilation – the patient should always have spontaneous efforts. If the patient isn't breathing spontaneously, then there is a need to be more vigilant of the PaCO2. Paralysing agents should be avoided in APRV mode. Target a RASS score of -2 to 0
Assess expiratory flow **Adjust t-low setting**	Assess the peak expiratory termination point – should be **50 to 75%** of the peak expiratory flow. If oxygenation is stable, consider increasing t-low to 0.1 second increments to obtain a termination point equal to 50%.
Increase minute vent by: ▪ **Increasing the p-high or** ▪ **Decreasing the t-high**	Increase p-high in 2 to 4 cm H2O increments, while assessing patient's haemodynamic status. This setting may be increased up to 30cm H2O. If compliance is low, it may be necessary to increase this setting > 30 cm H2O (anything up to 40cm H2O may be needed). Consider – decreasing the t-high if oxygenation status is stable. This will allow for more releases. Remember decreasing t-high will lower mean airway pressure and may compromise oxygenation. It may be better to accept hypercapnia than to reduce mean airway pressure (p-high and t-high) so much that oxygenation decreases.

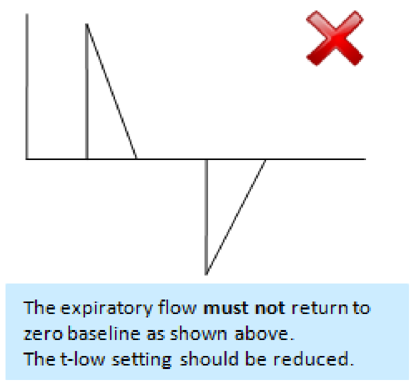
Example of possible settings

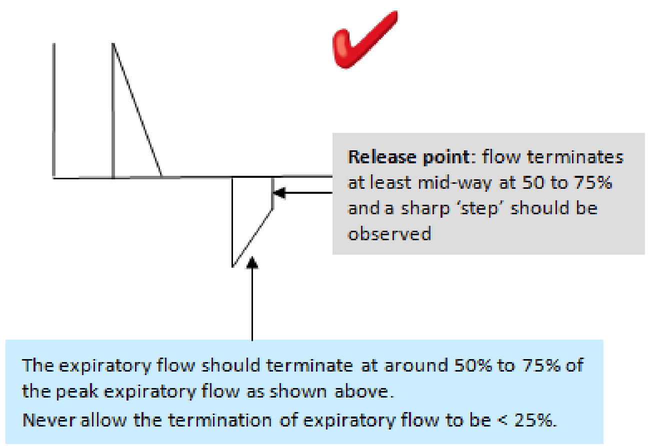


Monitoring guidance when using APRV

Observe the expiratory flow

It is important to examine the flow-time curve to make sure that the lung is not emptying completely





If the release point is at 75% **and** PaCO2 is too high, consider increasing the t-low – but **only slow changes** are recommended, in increments of 0.05 to 0.1 seconds

Record the mandatory respiratory rate

- The respiratory rate is derived from the t-high (or inspiration time) and t-low (or expiration time) settings
- If t-high is 5 seconds and t-low is 1 second = 6 seconds duration for each breath that is delivered
- 60 ÷ 6 = 10 mandatory breaths per minute
- Record the t-high and t-low settings on the patient's observation chart
- It is best, when possible, to have 12 releases/min or less per minute, otherwise too many release breaths might compromise mean airway pressure and oxygenation. **The release breath will generate the true tidal volume**

Record the number of spontaneous breaths

- Small, frequent spontaneous breaths should be noted. The tidal volume and minute volume will be variable
- As recruitment takes place, the tidal volumes during releases and during spontaneous breathing may increase. This might indicate an improvement in the patient's lung condition

Monitoring tidal volume

- There is a potential for excessive Vt delivery if lung or chest wall compliance improves and Vt increases significantly for the same pressure settings
- If the tidal volume is inadequate, the expiratory time is lengthened
- If the tidal volume is too high, the expiratory time is shortened

Record the intrinsic PEEP and gas trap values

- To obtain intrinsic PEEP and gas trap values → Select 'Procedures Menu' → Diagnostics

Weaning from APRV

When the FiO2 is titrated below 0.60, recruitment is maximised, and the patient is breathing spontaneously, a continuous gradual wean **can begin by**

- Decreasing the p-high by 1 to 2cm H2O and increasing the t-high by 0.5 seconds for every 1cm H2O drop in p-high. This is referred to as 'drop and stretch'
- 'Drop and stretch' should be done every 2 hours or more if tolerated
- As the 'drop and stretch' progresses, the mean airway pressure is gradually lowered and oxygen saturations need to be closely monitored. It is important to stress that the p-high setting should not be weaned too rapidly as this may reduce the mean airway pressure too quickly and may also result in severe (and irreversible) de-recruitment
- Throughout the weaning process, the patient should be closely monitored for increased work of breathing, tachypnoea or a drop in oxygen saturations. **If this occurs, return to the previous settings**
- The goal is to arrive at a p-high of around 10cm H2O with t-high approximating 12 to 15 seconds
- When the p-high reaches 10cm H2O and the t-high reaches 12 to 15 seconds, the following transitions may be approached depending on the clinician's preference:
    - Change the mode to CPAP/ASB: 10cm PEEP + 5cm ASB **or** it may be considered appropriate to proceed to extubation