INSPIRE - 100

An Emergency Ventilator Device

Frequently Asked Questions

TekMedika

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Glossary of Acronyms

The table below summarizes all the abbreviations used in this document.

Symbol	Variable	Description
VT	Tidal Volume	Volume of air delivered each inspiration phase (ml)
RR	Respiratory Rate	Breaths per minute
E/I	Expiration/Inspiration ratio	Ratio of expiration vs inspiration time in a breath cycle
PMAX	Max Inspiration Pressure	MAX inspiration pressure never to be exceeded (cm H_2O)
PEAK	Peak Inspiration Pressure	Max pressure during Inspiration phase of breath delivery (cm H_2O)
PLAT	Plateau Pressure	Plateau pressure during breath delivery (cm H_2O)
PEEP	Peak End Expiration Pressure	Pressure in the lungs that exists at the end of expiration (cm H_2O)
PS	Pressure Support	Level of support pressure to assist patient-initiated (spontaneous) breaths (cm H_2O)
TPS	PS Inspiration duration	Termination of the inspiration phase for which the pressure support is to be delivered. It can be Flow controlled (%age of Peak Flow) or Time controlled (secs).
FiO_2	Fraction of Inspired Oxygen	Concentration of oxygen in the inspired air. This is guided by the system but controlled outside the system in the Oxygen source. (%age)

Why is INSPIRE-100 suitable only for adult patients?

The main difference between adult and paediatric ventilators is the range of flows and volumes they can deliver. The ranges that INSPIRE-100 can deliver are suitable only for adult patients.

Neonatal and Paediatric ventilators deliver lower flows and volumes at faster rates and deliver breaths with a shorter response time to patient-triggered effort compared to adult ventilators.

What is Non-invasive ventilation?

Using a face mask to get air from the ventilator into your lungs is called non-invasive ventilation. The face mask fits tightly over the patient's nose and mouth to help the patient breathe. This method is recommended if the patient's breathing problems are not severe enough to require a breathing tube. This method is also used to help the patient get used to breathing on his own after the breathing tube is removed.

The benefits of this type of ventilation are as below.

- It can be more comfortable than a breathing endotracheal tube.
- It allows the patient to cough.
- The patient may be able to talk and swallow.
- The patient may need less sedatives and pain medicines.
- It lowers some risks, such as pneumonia, that are associated with an endotracheal tube.

What is Invasive ventilation?

In more serious cases, a breathing tube is placed into the patient's windpipe, and the breathing tube (also called an endotracheal tube) is connected to a ventilator that blows air directly into the patient's airways. The process of inserting the tube into the patients's windpipe is called intubation.

Usually, the breathing tube is inserted into the patient's nose or mouth. The tube is then moved down into the throat and windpipe. The endotracheal tube is held in place by tape or a strap that fits around the patient's head.

How do you decide between Invasive and Non-Invasive ventilation?

This decision is the responsibility of the attending Intensivist / Pulmonologist.
It is pertinent to point out that there are many recent studies that point to the efficacy and lack of complications from a Non-Invasive ventilation strategy. There are instances where Invasive Ventilation is the only option.

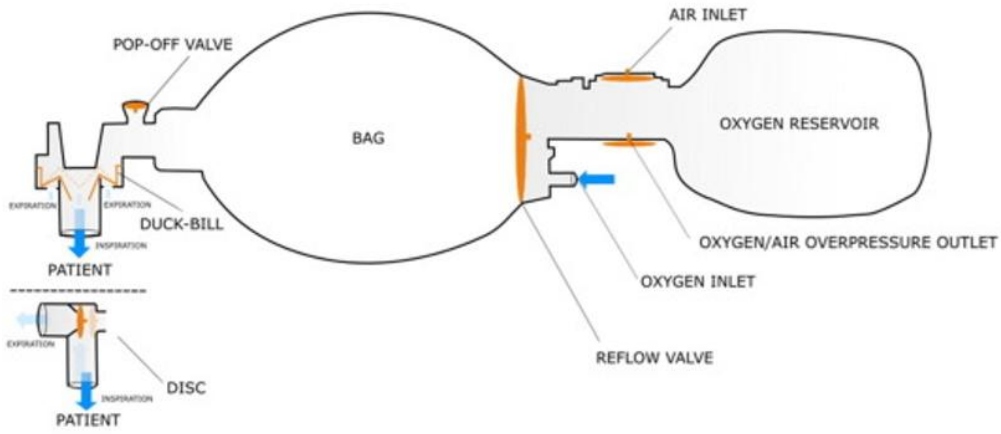
What is “weaning”?

"Weaning" is the process of gradually reducing ventilator support to the point when the patient can start breathing on his own. Once the patient shows that he can successfully breathe on his own, he is disconnected from the ventilator.

What is a BVM bag?

A bag valve mask (BVM), sometimes referred to as an Ambu bag or a Manual Resuscitator Bag, is a self-inflating bag used to provide ventilation to the person not breathing normally. It consists of a self-inflating bag, one-way valve, mask, and an oxygen reservoir.

What are the various inlet/outlet ports of a BVM bag?



The bag-valve-mask (BVM) device features several critical inlet and outlet ports that facilitate effective ventilation.

- **Oxygen Inlet**: This port allows for the connection of an oxygen source, enabling the delivery of enriched oxygen to the patient. It is essential for improving oxygenation during resuscitation efforts.
- **Reflow Valve:** This one-way valve ensures gas is only delivered forward to the patient during manual ventilation, but not backward into the reservoir bag**.**
- **Air Inlet:** This is essential for the self-inflating property of the BVM bag. During spontaneous breathing, if the oxygen supply flow cannot meet the patient's inspiratory flow and the oxygen reservoir bag has been emptied, this valve will open and entrain room air. This situation can also occur during mandatory ventilation if the tidal volume and ventilation rate are high, and the oxygen supply flow is inadequate. In such case, when the ventilation bag recoils in the expiratory phase, the valve will open and entrain room air.
- **Oxygen/Air Overpressure Outlet:** With increasing oxygen flow, pressure will build up in the oxygen reservoir bag, and at a certain threshold the valve will open to atmosphere. This prevents the patient from being exposed to dangerous pressures caused by excessive flow from the oxygen source.
- **Pop-off Valve**: At a certain threshold this valve will open to atmosphere. This prevents the patient from being exposed to dangerous pressures.
- **Duck-bill Valve**: This valve prevents exhaled air from re-entering the BVM bag, thereby minimizing carbon dioxide buildup in the patient’s system. It typically remains closed during inspiration but opens at the end of each breath to allow expired air to escape, thus preventing rebreathing.

These ports work together to ensure that the BVM bag functions effectively in providing positive pressure ventilation to patients who are unable to breathe independently. Proper understanding and usage of these ports are crucial for healthcare providers during emergency situations.

When should the BVM bag be replaced?

BVM bags have a limited lifetime and must be replaced if they fail to deliver desired pressures/volumes, show signs of fatigue, or between patients. The system issues a warning when it is time to replace the one in use. In addition, the BVM bag should be monitored for signs of fatigue every 4 hours of use. Inspire-100 has been tested with the Surginatal Disposable Resuscitator BVM.

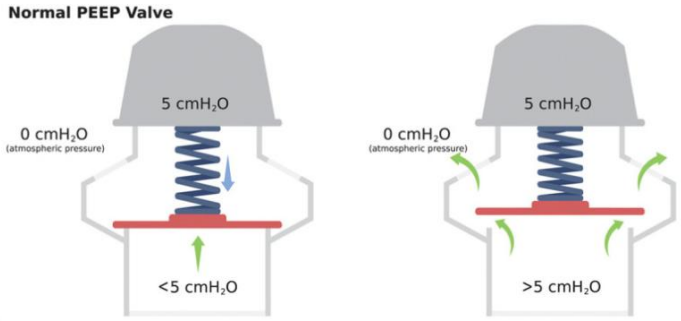
What is an oxygen reservoir?

A bag valve mask can be used without being attached to an oxygen tank to provide "room air" (21% oxygen) to the patient. However, BVM devices also can be connected to a separate bag reservoir, which can be filled with pure oxygen from a compressed oxygen source, thus increasing the amount of oxygen delivered to the patient.

An oxygen reservoir has two one-way valves. The properties of the reservoir are as below.

- Reservoir must be at least the volume of the bag.
- Oxygen flow rate equal to, or higher than, the minute volume of the patient allows 100% oxygen to be delivered.
- Inlet valve allows room air to enter if fresh gas flow is inadequate and an outlet valve allow oxygen to flow out if pressure is excessive.

What is a PEEP valve?



PEEP valves are adjustable pressure release valves. They are commonly used in conjunction with bag valve masks (BVMs) and vent exhaled gases to the atmosphere. When the pre-valve pressure exceeds the valve setpoint, a diaphragm opens and allows flow. When pre-valve pressure drops below the valve setpoint, the diaphragm closes and flow across the valve stops.

What is a HEPA/HME filter?

Heat and Moisture Exchanger Filter (HMEF) is usually incorporated with a microbiological filter that provides passive humidification.

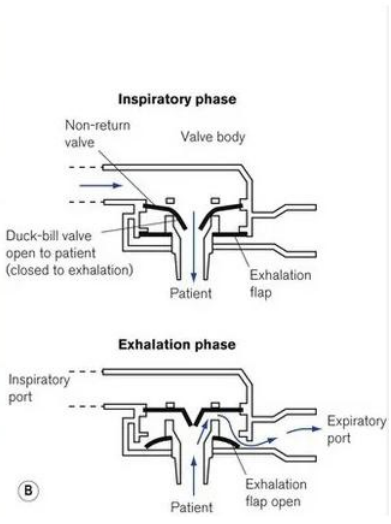
A pleated high-performance HEPA filter is integrated with Heat and Moisture Exchanger (HME) to support infection control in ventilation treatment.

These filters typically Include a gas sampling port with tethered strap and cap.

Hydrophobic media supports bacterial/viral efficiency of 99.99%.

What is a Non-Rebreathing valve?

Non-rebreathing valves prevent rebreathing of the gases by ensuring unidirectional flow of gases. The inhaled and exhaled gases follow different paths, and the exhaled gas never finds its way into the inhalation tube.

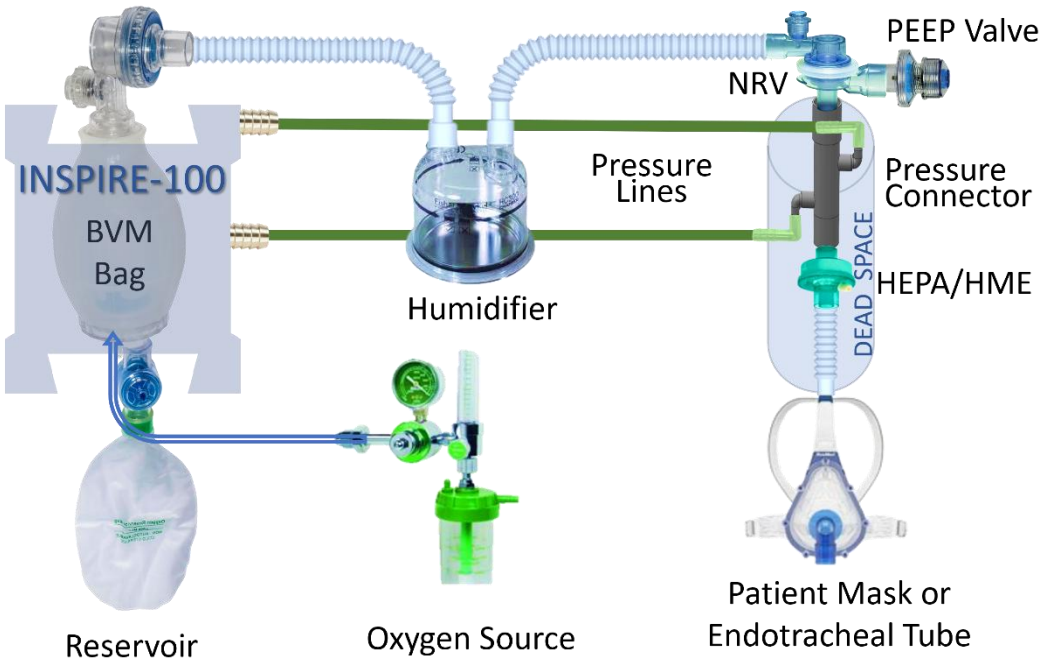


What is respiratory dead space?

Dead space simply means volume in the respiratory circuit that does not participate in gas exchange in the lungs. Gas exchange occurs at the alveoli in our lungs so every anatomical structure above it is dead space. This includes the nasal/oral passages, pharynx, larynx, trachea, and the bronchi.

In a patient who is not on a ventilator, the source of gas is the ambient air, and the anatomical dead space starts at the mouth opening. In a ventilator patient, the source of gas is the ventilator and its tubing.

The breathing circuit for Inspire-100 is as in Figure below. The blue-cylindrical area is the ventilator dead space. The key point is that the inspiratory limb is constantly filled with fresh gas and can be thought of as an extension of the ventilator itself. So, for all practical purposes, the source of gas in a ventilated patient is the Non-Rebreathing-Valve component of the ventilator circuit.



Any equipment that is between the patient and the Non-Rebreathing-Valve constitutes dead space (in addition to the anatomical dead space itself). At minimum, this includes the endotracheal tube in an intubated patient. Other potential sources include heat and moisture exchanger (HME) etc. It is important that the Non-Rebreathing-Valve be placed as close to the patient as possible to reduce dead space to a minimal.

Does INSPIRE-100 support BiPAP ventilation mode?

The non-invasive BiPAP mode of ventilation is similar to the PSV mode with a patient mask. The table below is a quick comparison.

Comparison	PSV	BiPAP
Invasive/Non-invasive	Invasive	NIV
Needs an intact patient's drive to breathe	Yes	Yes
Patient triggered breaths are pressure supported	Yes	Yes
Constant pressure at the end of the breath	PEEP	EPAP
Pressure delivered when breath initiated	PS	IPAP
Patient controls inspiration duration and breath cycling	Yes	Yes

To emulate BiPAP using BiPAP terminology, set INSPIRE-100 ventilation mode to PSV, set PEEP to desired EPAP value, and set PS to desired IPAP value. You also need to choose a proper setting for TPS. (See section on PSV v/s BiPAP).

There is an additional feature provided by INSPIRE-100 via the Minute Volume parameter. If the Minute Volume parameter is set to anything other than "---" (don't-care), the minute volume is monitored during PSV mode and alarms are issued if the measured value falls short of the desired set value. If this condition persists, the PSV mode is replaced by SIMV mode automatically.

Why block the breathing outlet during pre-use checks?

INSPIRE-100 has two pressure tubes connecting to the system from the breathing circuit. These are the upstream and downstream pressure tubes respectively. The system checks for proper connection of the upstream and downstream pressure tubes by detecting the blocked outlet.

Since it is not advisable to have the patient connected during Pre-use checks, a simpler process is to simply block the breathing tube outlet with the fleshy portion of your palm to enable the system to perform this check.

Does INSPIRE-100 monitor FiO2?

INSPIRE-100 doesn't have an internal oxygen sensor. You can use an accessory FiO2 monitor, and SpO2 pulse oximetry to monitor patient oxygenation. See the Inspire-100 Operating Manual for more information on FiO2 flow and minute ventilation.

Why is the target pressure or volume not achievable sometimes?

It depends upon the size of the BVM bag and whether it is fatigued. Adjust the respiratory rate (RR) or inspiratory to expiratory time ratio (I:E ratio). Check the breathing system for obstructions or kinks. Replace the BVM bag.

Which parts should be replaced or cleaned between patients?

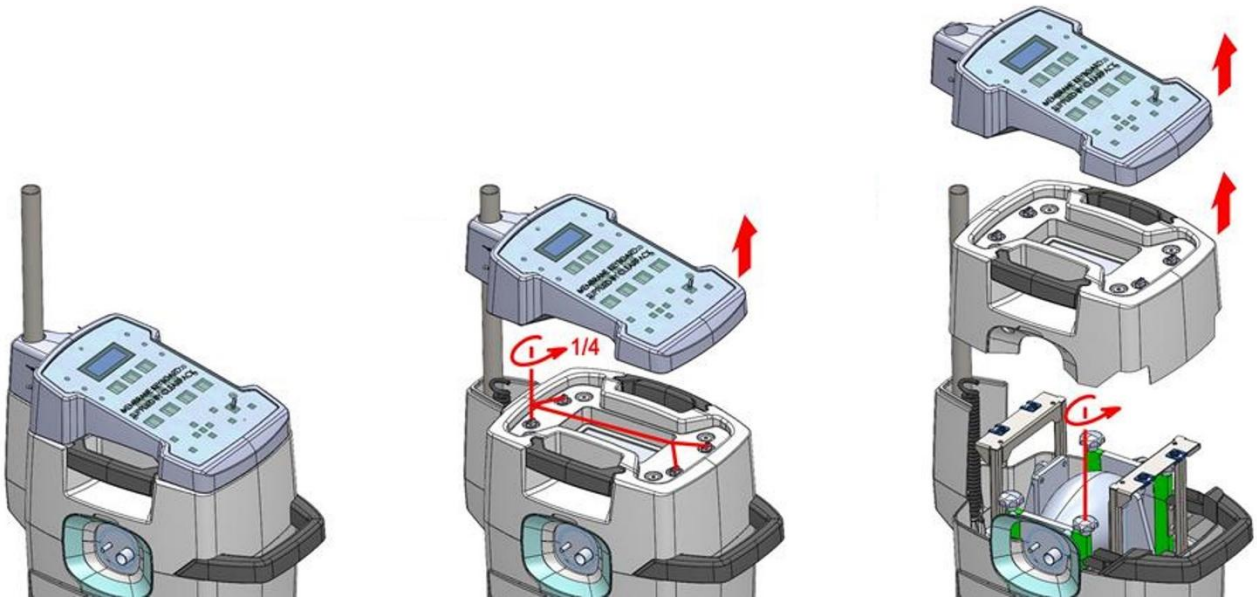
Replace all parts outside of the INSPIRE-100 chassis between patients. These include the external ventilator tubing, filters, HME, patient valve assembly, and pressure sensing tubing. The BVM bag, inside the chassis, should also be replaced between patients.

What is the process to replace the BVM bag?

BVM bags have a limited lifetime and must be replaced periodically. The system keeps track of the number of compressions the BVM bag has undergone. The system issues a warning message when it is time to replace the BVM Bag.

When the BVM Bag has been replaced, this count must be reset to zero. The system does so properly if the proper process is followed – otherwise the system must be forced to undergo a FACTORY RESET manually after replacing the BVM Bag.

The recommended process to replace the BVM Bag is as follows.



1. Power-up the system and follow instructions till the Pre-use checks menu is presented on the LCD screen.

2. Navigate the menu to “Recommended>Breathing System>BVM Bag” and follow instructions.
3. Power-down the system.
4. Loosen the Control Panel clamp on the pole as shown in the Figure below.
5. Slide the control Panel upwards.
6. Unscrew the BVM cover. There is no need for a screwdriver or any other tool for this. The screws can be turned by hand.
7. Install the BVM bag between the mounts.
8. Screw the BVM cover back on.
9. Slide the Control Panel down and clamp it back on the pole.
10. Power-up the system again.
11. Follow instructions on the LCD screen.

What is “System Needs Servicing” warning message?

After prolonged use, it is recommended to get the system serviced. The system keeps track of the number of machine cycles the system has undergone and issues a warning at the appropriate time.

Servicing must be done by our Service engineer. It involves inspecting all the moving mechanical parts of the system and replacing them if necessary. After the servicing, the Service engineer will restore the system to factory settings.

What patient monitoring is recommended with INSPIRE-100?

It is recommended to monitor patient arterial blood gases and SpO_2, at a minimum. If you use Assist Control, it is also recommended that you conduct CO_2 monitoring as well.

Why does INSPIRE-100 ask for deployment altitude?

The system uses the altitude to determine ambient pressure and oxygen content for its algorithms. This information only needs to be entered once during installation or relocation. Once entered, the system stores and uses this information for all subsequent runs.

This information is readily available at the URL below.
https://www.freemaptools.com/elevation-finder.htm

Why does INSPIRE-100 provide different types of RESET?

For ease-of-use, the system stores some information across power cycles i.e. the information is retained even after the system is powered down. This information includes details such as WiFi network name, patient details and some input settings. Different types of RESET treat this non-volatile information differently.

Normal RESET
: All stored information is retained.

Factory RESET
: All stored information is erased.

Watchdog RESET
: This is a system generated RESET that the user has no control over. This type of RESET is triggered if the system detects some unrecoverable error situation. In this case, all stored information is retained. It is important to note that the watchdog RESET should never ever happen – the mechanism is provided only for fail-safe protection.

How to keep WEB dashboard tab active in the browser?

Some browsers, like Google Chrome and Microsoft Edge, have a sleep mode that puts tabs to sleep after a period of inactivity. This helps conserve memory and power, but it can cause the WEB dashboard to be deactivated if the tab is in the background for some period.

In Google Chrome, you can add sites to be kept active by following these steps:

1. Open Chrome and click the three vertical dots in the top right corner
2. Select Settings
3. Click Performance on the left menu
4. Click Add to the right of "Always keep these sites active"
5. Choose to add sites from currently open tabs or manually

Where is the WEB dashboard recording saved?

INSPIRE-100 dashboard saves the recording database in the browser on the disk of the computer being used. Thus, the recording saved on one browser is not directly available on another browser even though it may be on the same computer. Use the import/export feature to transfer the recording database between browsers or between computers.

Once created, the recording is accessible forever unless explicitly deleted by the user. Both the Recorder and Playback Apps allow deletion of selected recordings.

Why does the Dashboard occasionally report Packet loss?

The INSPIRE-100 system communicated with the remote Dashboard via the local Wi-Fi followed by the Internet in the cloud. Occasional packet loss can occur due to internet congestion when communicating with the remote dashboard.

The Dashboard indicates the missing interval but does not stop monitoring and the rest of the intervals are correctly captured and displayed. This is an extremely rare occurrence.

Captive portal does not automatically open upon network login?

To enter certain information into the system, the system requires you to login into a specific Wi-Fi network that it creates temporarily. If the captive portals for Location, Patient of WiFi credentials do not open automatically upon logging into the appropriate network, do the following.

On your mobile device, “Forget the network” and re-login. All mobile devices have an option to forget a particular network, thus resetting the device settings for that network.

APPENDIX

Breath Cycling in PSV v/s BiPAP

Pressure support ventilation (PSV) and bilevel positive airway pressure (BiPAP) are both modes of non-invasive or invasive mechanical ventilation, but they differ in how breaths are cycled and controlled, which explains why PSV requires a parameter for terminating flow percentage while BiPAP typically does not.

Key Differences in Breath Termination

PSV: Flow-Cycled Inspiration

How Breath Ends: In PSV, inspiration is terminated based on a flow criterion—specifically, when the inspiratory flow decreases to a set percentage (commonly 25%) of the peak inspiratory flow. This is called flow-cycling.

Why Needed: The flow termination parameter is essential because PSV is designed to support spontaneous patient breaths. Since each breath is patient-initiated, the ventilator must detect when the patient's inspiratory effort is ending. As lung compliance and resistance vary among patients, the flow termination percentage ensures the ventilator cycles to expiration in synchrony with the patient's own neural or muscular respiratory timing. Without this parameter, inspiration could end too early or too late, causing patient-ventilator asynchrony.

Technical Need: The flow decay percentage (terminating flow) is a critical ventilator setting in PSV to ensure that the breath ends at the appropriate time, matching the patient's physiology.

BiPAP: Time-Cycled or Dual-Level Pressure

How Breath Ends: In BiPAP, the transition from inspiratory positive airway pressure (IPAP) to expiratory positive airway pressure (EPAP) is typically time-cycled, especially in spontaneous/timed (S/T) mode. In this mode, the device switches between IPAP and EPAP after a set inspiratory time or when the patient stops breathing (for a backup rate).

Why Not Needed: BiPAP does not rely on flow termination to cycle between IPAP and EPAP. Instead, it uses preset timing or patient effort to switch. In spontaneous mode, it may also use a minimal flow or pressure change to detect patient effort, but it does not require a specific flow termination percentage as a primary cycling mechanism.

Technical Simplicity: The absence of a flow termination parameter simplifies BiPAP operation and is suitable for most noninvasive ventilation scenarios, where precise synchronization with the patient's neural inspiration is less critical than in invasive PSV.

PSV v/s BiPAP Summary Table

Feature	PSV	BiPAP/Bilevel Ventilation
Inspiration Termination	Flow-cycled (based on % of peak flow)	Time-cycled or patient effort
Flow Termination Parameter	Required	Not required
Main Use	Invasive and some noninvasive support	Primarily noninvasive support
Synchronization with Patient	High (matches neural inspiration)	Moderate (relies on timing/effort)

Conclusion

PSV requires a parameter for terminating flow percentage because it is designed to closely match the patient's own respiratory cycle by ending inspiration when inspiratory flow drops to a set level, ensuring optimal patient-ventilator synchrony. BiPAP, on the other hand, typically cycles between pressure levels based on time or minimal effort, so it does not need a specific flow termination parameter.