



AutoFlow®

The Oxylog 3000 plus incorporates the benefits of pressure controlled ventilation into volume controlled ventilation

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Foreword

Dear reader,

Performing mechanical ventilation during emergency care is a real challenge. Especially in out-of-hospital situations there are many problems to solve in a minimum of time. In addition, environmental factors play an important role in the performance that can be achieved.

In emergency situations, patients often have spontaneous respiratory efforts. However, when mechanical ventilation is needed in the field, many health care providers prefer volume controlled ventilation modes. Deep sedation is needed to let the patient accept this kind of ventilation, often complicated by negative effects on circulation and resulting in possible secondary brain injury or increased stress to the heart.

With AutoFlow[®] spontaneous ventilation efforts of the patient are accepted in volume controlled modes, resulting in less stress, reduced need for deep sedation and better pressure control. The emergency care provider's ability to stay in control of the whole situation is improved.

This booklet provides an overview of the different aspects of AutoFlow and focuses on emergency care and transport ventilation with the Oxylog 3000 plus. It aims to answer the main questions that you might have and describes the areas where AutoFlow could contribute to the ventilation therapy applied in this field.

We hope this booklet provides information which helps you provide safety and comfort for your ventilated patients!

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Important notes

Medical knowledge is subject to constant change due to research and clinical experience. The authors of this publication have taken utmost care to ensure that all information provided, in particular concerning applications and effects, is current at the time of publication. This does not, however, absolve readers of the obligation to take clinical measures based on their own medical knowledge and judgment.

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Explanatory notes:

In some regions of the world VC-CMV mode of ventilation is referred to as IPPV. IPPV Assist is identical to VC-AC. The mode BIPAP* is referred to as PC-SIMV+ in the USA and Canada.

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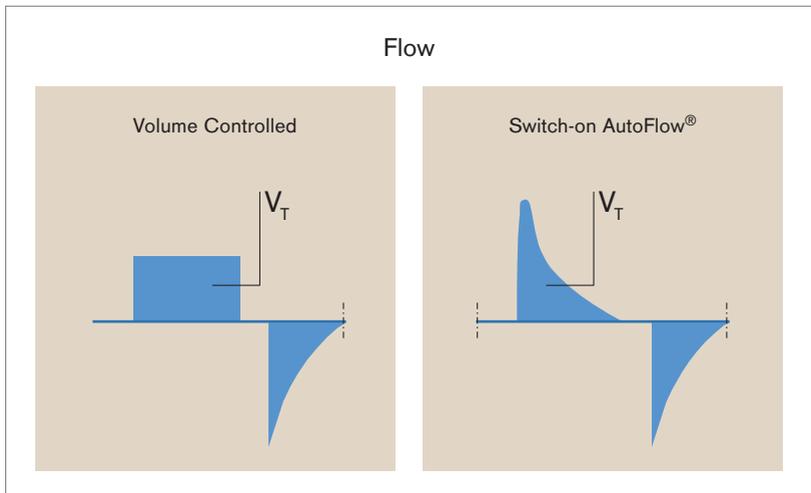
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1. What is AutoFlow?

AutoFlow is an adjunct to volume controlled ventilation mode, it automatically regulates inspiratory flow and inspiratory pressure. When AutoFlow is activated the inspiratory flow pattern changes from the constant flow typical of volume controlled ventilation to a decelerating flow pattern usually associated with pressure controlled ventilation.

AutoFlow

- Is available in all volume controlled modes such as VC-CMV, VC-AC, VC-SIMV, VC-SIMV/PS.
- Delivers the set tidal volume at the lowest possible inspiratory pressure.
- Reduces peak airway pressures.
- Allows the patient to breathe any time in the respiratory cycle.



Fixed flow pattern versus decelerating flow pattern delivering identical tidal volume.

2. How is AutoFlow set up?

AutoFlow is an adjunct to volume controlled ventilation mode. It is found in the Oxylog 3000 plus “settings” menu. Once the function has been selected it is switched on by pressing the rotary knob.

There is no need to change other settings or alarm limits once AutoFlow is activated as long as they meet clinical needs. The P_{max} setting has an additional function during AutoFlow: it limits the inspiratory pressure control to a level of 5 mbar below the P_{max} setting.

AutoFlow is only available in volume controlled modes.



3. What happens when AutoFlow is activated?

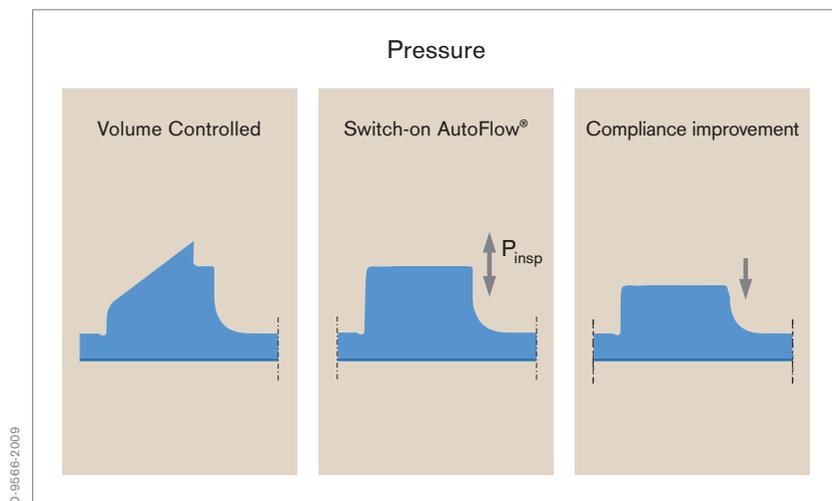
Once AutoFlow is activated the next mandatory ventilation stroke is delivered with the minimal flow required to deliver the set volume within the set inspiratory time. The resulting end inspiratory pressure is used as the inspiratory pressure for the next breath.

Subsequently a decelerating inspiratory flow profile is used. Once expiration begins delivered (inspiratory) volume is compared to the set tidal volume. The inspiratory pressure of the next mandatory stroke is adjusted, up or down, according to the measured inspiratory volume of the previous breath.

The inspiratory pressure is adjusted by a maximum of plus or minus 3 mbar per breath. The inspiratory pressure will not increase to more than 5 mbar below the upper airway pressure alarm limit. If the set tidal volume can no longer be achieved, an alarm “VT low, pressure limit” is generated.

Spontaneous breathing may cause fluctuations in the tidal volume, however, AutoFlow ensures a constant tidal volume is applied, on average, over time.

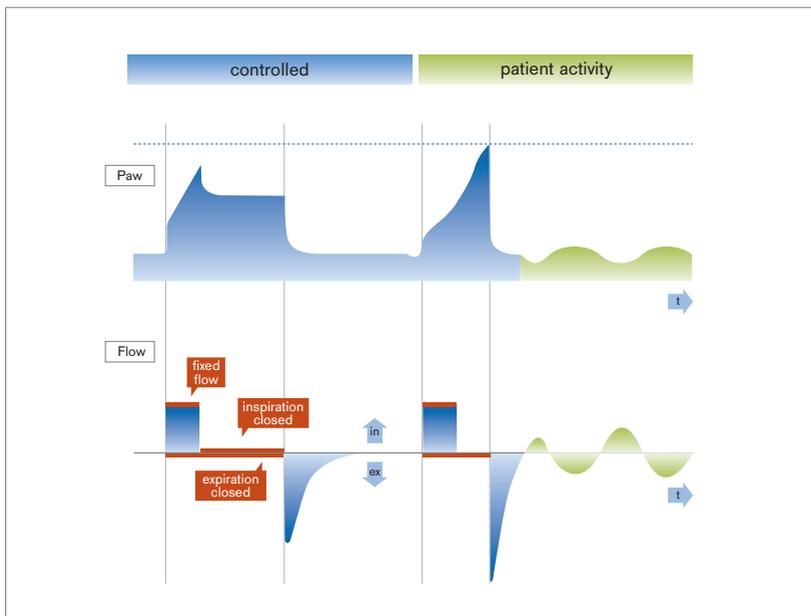
It is always possible and useful to use AutoFlow provided there are no specific pulmonary restrictions and the patient is receiving volume controlled ventilation.



4. How are spontaneous efforts mixed with mandatory volume controlled strokes?

Traditionally in volume controlled modes the ventilator closes the expiratory and opens the inspiratory valve for a defined period of time. After the gas has been delivered a pause (plateau) may occur and both valves are closed before the expiratory valve opens to enable expiration. Generally the ventilator does not respond to spontaneous efforts during such a mandatory stroke. High or low airway pressure alarms may be seen and are obvious indicators that the patient is fighting the ventilator.

Volume Control without Autflow

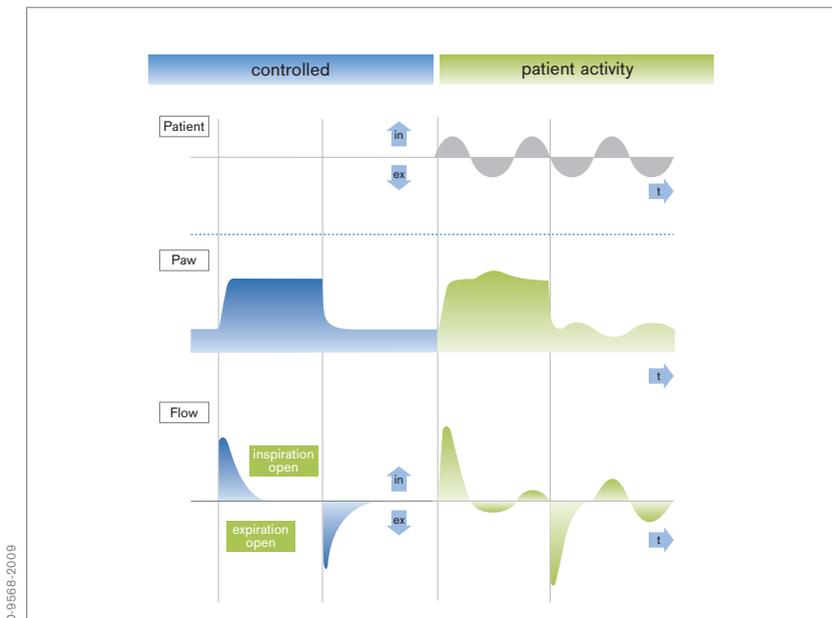


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Patient activity without AutoFlow

Several technical requirements have to be met to improve breathing comfort and reduce the invasiveness of mechanical ventilation: apart from the need to have a fast gas delivery system to meet additional flow requirements it is also necessary for the expiratory valve to respond immediately in case of pressure rises. This “Room to Breathe” concept was realized in the pressure controlled PC-BIPAP/PC-SIMV+ mode for the very first time. AutoFlow incorporates the same “Room to Breathe” principles as PC-BIPAP/PC-SIMV+, enabling spontaneous breathing throughout the respiratory cycle which facilitates stress-free volume controlled ventilation.

Volume Control with Autoflow



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Patient activity with AutoFlow

5. How does AutoFlow compare to PC-BIPAP*/PC-SIMV+ ?

Volume controlled ventilation with AutoFlow and PC-BIPAP/PC-SIMV+ both facilitate the “Room to Breathe” concept and allow the patient to breathe spontaneously at any time in the respiratory cycle.

PC-BIPAP/PC-SIMV+ is a pressure controlled mode and the tidal volume (VT) provided results from the pressure difference between inspiratory (P_{insp}) and expiratory (PEEP) pressure. Changes in lung compliance during PC-BIPAP/PC-SIMV+ cause changes in tidal volume.

AutoFlow follows a different strategy: As tidal volume is the primary parameter in volume controlled ventilation, changes in lung compliance conditions cause changes in the inspiratory pressure (while the volume remains stable). This is how AutoFlow supports volume protective strategies.

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	PC-BIPAP/PC-SIMV+	VC-SIMV/AutoFlow
Pressure & Trigger	PEEP P _{insp} Pressure Support Trigger	PEEP – Pressure Support Trigger
Time	RR Ti or I:E Slope	RR Ti or I:E Slope
Volume	–	VT

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Key settings in PC-BIPAP/PC-SIMV+ and VC-SIMV / AutoFlow

6. How does AutoFlow work with VC-CMV and VC-AC?

VC-CMV is a volume controlled mode and does not respond to patient effort. With VC-AC the patient can trigger additional mandatory strokes.

AutoFlow does not change the cycling characteristic of any mode and ventilation can be conducted as usual. When the patient starts making spontaneous breathing efforts AutoFlow increases or decreases the gas flow according to these efforts. Such an improvement in synchrony can reduce the frequency of airway pressure alarms and increase breathing comfort dramatically.

7. How does AutoFlow work with VC-SIMV?

VC-SIMV can be used on patients with spontaneous breathing. Settings of VC-SIMV can be combined with Pressure Support and set mandatory strokes are synchronized to spontaneous efforts.

AutoFlow automatically regulates inspiratory flow and inspiratory pressure during the mandatory strokes. AutoFlow can improve breathing comfort, especially if spontaneous breathing interacts with mandatory strokes. In such a case AutoFlow provides gas flow according to the patient's needs and prevents the patient from being starved of air. AutoFlow does not affect Pressure Support strokes.

In VC-SIMV/PS the total minute volume results from set volume ($RR \times VT$) plus spontaneous volumes.

8. What advantages are observed when using AutoFlow?

Patients who require ventilation in emergency situations often have spontaneous breathing efforts. Many healthcare providers prefer to ventilate patients in a volume controlled mode to ensure that the patient gets the tidal volume they need, especially in hectic situations where continuous control of the ventilator is not always possible. AutoFlow allows volume controlled ventilation to accept spontaneous breathing of the patient.

Deep sedation should be avoided as it may result in serious complications due to negative hemodynamic effects and reduced clinical (neurologic) control of the patient. AutoFlow makes it possible to ventilate patients in a volume controlled mode in situations where deep sedation or muscle relaxation of the patient to depress spontaneous breathing is not required. Spontaneous breathing contributes to better gas exchange and secretion clearance.

Greater comfort and less stress for patients should in turn reduce stress for medical staff.

Lower airway pressure results in a lower intra-thoracic pressure which has a positive effect on hemodynamics, as well as lowering intracranial pressure and reducing the chance of a (tension) pneumothorax.

Finally, the need to adjust fewer controls and reduced alarm management requirements are seen as beneficiary in hectic emergency care situations.

Summary: AutoFlow® minimizes airway pressures while ensuring a pre-selected tidal volume delivery providing improved safety

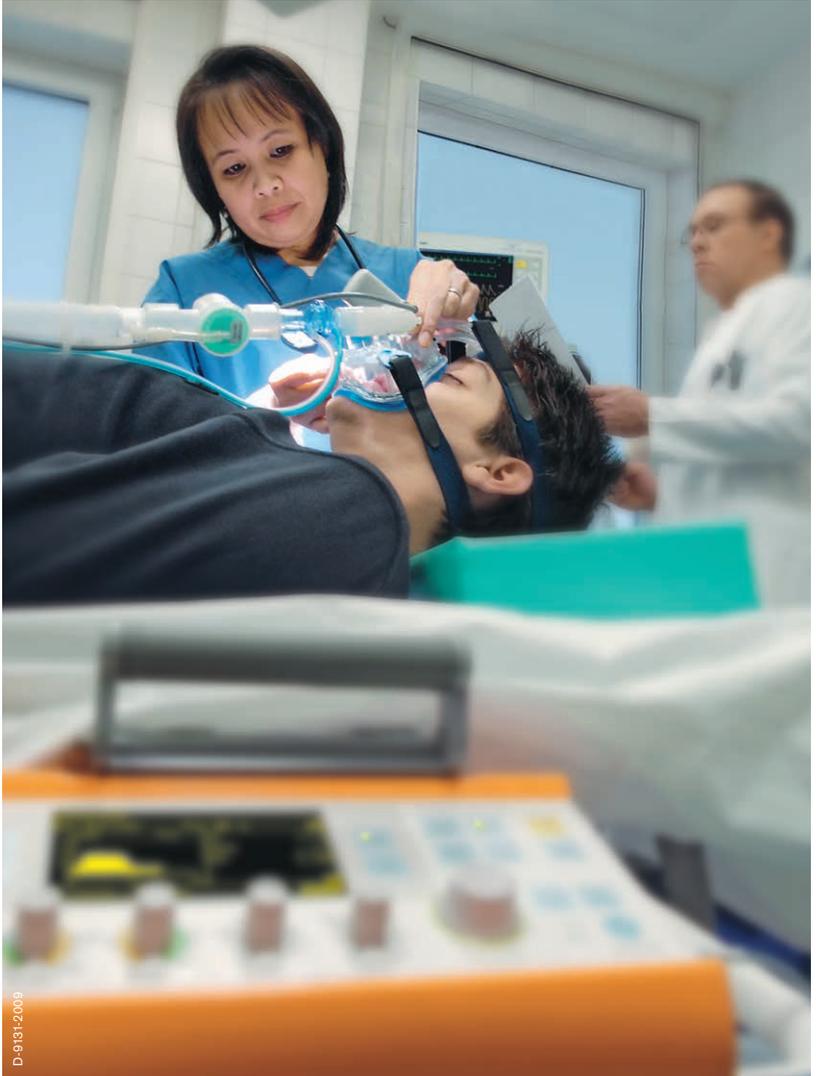
9. How do leaks (e.g. in NIV) affect AutoFlow?

Leaks often occur during mask ventilation and are compensated for by an additional gas flow from the ventilator. Pressure controlled modes automatically detect the drop in pressure caused by a leak and react to maintain the set pressure level.

AutoFlow enables non-invasive ventilation (NIV) to be applied in volume controlled modes and can help to increase patient compliance. When patients are ventilated with a mask the airway is not protected and gastric insufflation and subsequent aspiration of gastric contents may occur. This risk can be reduced when airway pressures are kept below 20 mbar/ cmH₂O.

When using AutoFlow in volume modes, a sudden increase in resistance (e.g. airway obstruction) does not result in a sudden rise in airway pressure; instead the inspiratory pressure is adjusted to a maximum of 3 mbar/cmH₂O breath to breath. The maximum inspiratory pressure in AutoFlow is limited to 5 mbar/cmH₂O below P_{max}. For example: if P_{max} has been set to 25 mbar/cmH₂O, the maximum inspiratory pressure will not rise above 20 mbar/cmH₂O.

When AutoFlow is used, changes in inspiratory pressure may be seen from breath to breath. Reasons for such pressure adaptations can be lung compliance changes, patient efforts as well as variations in leaks. If clinical circumstances require stable pressure conditions or leaks vary widely, pressure controlled modes are a preferred ventilation strategy.



10. When can AutoFlow be used?

Indications and contra indications of AutoFlow are based on the limitations of volume controlled modes. Independent from the AutoFlow function volume controlled ventilation may not be indicated where there is a risk of intrinsic PEEP and the associated danger of overinflating the lung in volume controlled strategy. This applies especially if obstructive disorders are present or long inspiration times and relatively short expiration times (inverse ratio) are required. In these cases pressure controlled modes like PC-BIPAP/PC-SIMV+ are preferred because of stable pressure conditions and an improved intrapulmonary gas distribution. Pure pressure controlled modes are also favored in patients with uncuffed tubes or in adult patients with significant and varying leaks.

Volume controlled modes combined with AutoFlow are indicated whenever the volume applied should remain stable and changes in inspiratory pressure (as typical for any volume controlled mode) are tolerable. In terms of patient types there are those with quite variable compliance levels e.g. after open chest surgery or due to re-positioning. Here a volume controlled mode combined with AutoFlow is easier to handle than pressure controlled ventilation where careful manipulation of pressure levels is considered necessary to keep the volume stable and to prevent hyper- or hypoventilation.

Emergency patients tend to have spontaneous breathing efforts, continuously or during painful or stressful events. This often results in reduced synchrony with the ventilator causing high or low airway pressures, which in turn can result in serious side effects such as increased intracranial pressure, reduced oxygenation, worsening of hemodynamics, etc. AutoFlow combines volume controlled modes with the possibility of synchronization of the ventilator to the patient's breathing efforts, resulting in fewer side effects as mentioned above.

Finally, AutoFlow is suitable for all start up ventilation therapy scenarios where there is limited information on disease status available and it is important to get therapy underway where pressures and flow are regulated and spontaneous activity is not compromised.

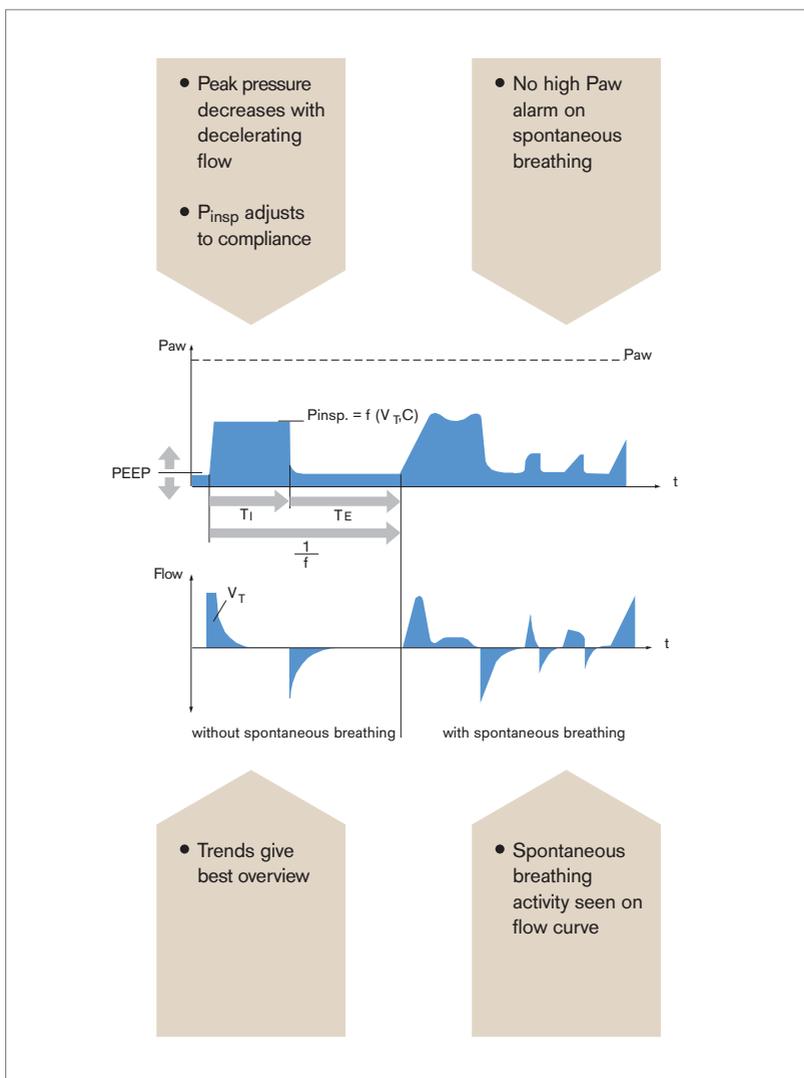
Summary: Volume or pressure ventilation strategy has to be selected according to the specific lung disease.

11. What monitoring parameters are important to observe when using AutoFlow?

All monitoring used in regular volume controlled modes is also of importance when using AutoFlow. The set tidal volume has to be adjusted on a regular basis according to the patient's needs, most often following arterial blood gases (ABGs) or according to the end-tidal CO₂.

For patient safety, all alarm limits have to be set and should match the current clinical conditions. Pulmonary changes as well as spontaneous breathing activities should be observed and monitored carefully. Spontaneous breathing activity can be seen on the flow curve or on the capnogram. No high Paw alarm will activate on active expiration. In addition, resistance and compliance changes affect ventilation pressures and flow curves.

In activating AutoFlow the peak pressure will decrease as flow decelerates. P_{insp} will adjust when compliance alters. As a result mean airway pressure will follow accordingly. The tidal volume applied may vary slightly but the average volume equals set tidal volume. Therefore changes in airway resistances are not seen in the pressure curve but influence the flow pattern significantly when AutoFlow is active. If airway resistances increase it will take longer to apply and to release a certain amount of volume.



If the V_T is not delivered a V_T low alarm or MV low alarm is generated.

12. What safeguards are there against hypo/hyperventilation?

As in all ventilation modes Minute Volume High and Low alarms are obligatory to ensure that the patient is adequately ventilated. In case of triggered modes the respiratory rate is monitored by the High Respiratory Rate alarm. The High Airway Pressure alarm warns in case of extreme coughing or obstruction.

In addition AutoFlow offers the following three safeguards:

- If the VT that is supplied to the patient exceeds the set VT by 30%, the inspiratory phase is automatically terminated. This prevents too high a VT being delivered, in case of, for example, a rapid increase in compliance.
- Rapid triggering by the patient does not lead to hyperventilation in the modes VC-SIMV/AF and VC-CMV/AF. If hyperventilation occurs in the mode VC-AC/AF the trigger can be turned off. In that case the patient is still able to breathe spontaneously.
- If lung compliance changes, AutoFlow adjusts the inspiratory pressure, breath by breath, by a maximum of 3 mbar/cmH₂O per breath. The maximum inspiratory pressure is limited to 5 mbar/cmH₂O below the set P_{max}. If the set VT cannot be reached due to this pressure limit, AutoFlow provides the alarm "VT low, pressure limit".

13. What is the value of AutoFlow in patients with head injury or stroke?

In patients with head injury or stroke it is of utmost importance to prevent secondary brain damage due to hypoxia, hypoperfusion or increased intracranial pressure (ICP). When these patients are unconscious (Glasgow Coma Scale 8 or below), there is an indication for endotracheal intubation and ventilation.

In volume controlled ventilation PaCO₂ levels are maintained, which is important in preventing additional brain injury. However, in case of volume controlled ventilation without AutoFlow, there is a risk that the patient has spontaneous breaths, which can cause high airway pressures, followed by high intrathoracic pressures and possibly followed by high intra-cranial pressures, which should be avoided at all times.

Furthermore, when the patient has pulmonary injury in combination with head injury, the airway pressures should be maintained as low as possible for the same reasons.

AutoFlow could be applied to patients with head injury or stroke who are ventilated in a volume controlled mode because the airway pressures will be as low as possible and spontaneous breathing of the patient is possible without the rise in airway pressure.

Finally, when AutoFlow is used, there is less need for deep sedation, which improves neurologic control of the case of patients with head injury or stroke and has fewer negative circulatory side effects.

14. What is the value of AutoFlow after return of spontaneous circulation (ROSC)?

In the period after ROSC (after CPR), the patient's circulation is very fragile and therefore ventilation should be performed carefully. Because there is evidence that manual (bag) ventilation may cause hyperventilation with a worse outcome, mechanical ventilation is recommended for better control of ventilation and prevention of hyperventilation and high airway pressures.

Especially during this phase, AutoFlow could help to avoid the above mentioned side effects and might help to improve outcome after ROSC.

15. What is the value of AutoFlow in blunt thoracic trauma?

These patients are at high risk of developing acute lung injury or ARDS and ventilator associated complications. Airway pressures should be kept low in thoracic trauma to avoid increasing a pneumothorax even leading to a tension pneumothorax.

Also, in case of a pulmonary contusion, improvement of outcome can be achieved when spontaneous ventilation can be maintained.

For these reasons, AutoFlow can be applied when patients with thoracic trauma have to be ventilated in a volume controlled mode.

16. What is the value of AutoFlow in patients who are ventilated via a supraglottic airway?

The number of patients that are ventilated via a supraglottic airway (LMA-Laryngeal Mask Airway, Larynx tube etc.) is increasing in emergency care.

A supraglottic airway does not totally secure the airway but it is recognized as the second best step when endotracheal intubation is not possible or fails. When higher airway pressures are used, there is a risk of leakage around the cuff and gastric insufflation may occur.

In case of mechanical ventilation in a volume controlled mode, AutoFlow can be used as it enables control of airway pressures and spontaneous breathing is possible without excessive airway pressures which would cause the patient to “fight the ventilator”.

Abbreviations

ABG	arterial blood gases
AF	AutoFlow
ARDS	Acute respiratory distress syndrome
CPR	Cardiopulmonary resuscitation
ICP	intracranial pressure
NIV	Non-invasive ventilation
PC-BIPAP	Pressure Controlled – Biphasic Positive Airway Pressure
PC-SIMV+	Pressure Controlled – Synchronized Intermittent Mandatory Ventilation
PEEP	Positive End Expiratory Pressure
P _{insp}	Inspiratory pressure
P _{max}	Maximum allowed inspiratory pressure
ROSC	Return of Spontaneous Circulation
SIMV	Synchronized Intermittent Mandatory Ventilation
VC-AC	Volume Controlled - Assist Control
VC-CMV	Volume Controlled - Controlled Mandatory Ventilation
VC-SIMV	Volume Controlled - Synchronized Intermittent Mandatory Ventilation
VC-SIMV/PS	Volume Controlled - Synchronized Intermittent Mandatory Ventilation-Pressure Support
VT	Tidal volume

Summary

Benefits of Autoflow:

- Delivers set volume at lowest possible pressure in all volume modes (Question 1, page 8)
- Reduces peak airway pressures (Question 1, page 8 & Question 11, page 22)
- Enables spontaneous breathing at anytime in all volume controlled modes (Question 1, page 8, Question 4, page 13)
- Reduces the invasiveness of mechanical ventilation and (Question 4, page 12)
- Carries over benefits of PC-BIPAP/PC-SIMV+ to volume controlled modes (Question 4 & 5, page 12 to 14)
- Keeps the tidal volume stable even if lung compliance changes (Question 5, page 14 & Question 11, page 22)
- Can support volume protective strategies (Question 5, page 14)
- Prevents annoying alarms (Question 6, page 15 & Question 8, page 17)
- Improves synchrony between patient and ventilator (Question 6, page 15)
- Improves patient comfort (Question 6, page 15 & Question 7, page 16)
- Adapts flow to the patient's needs (Question 7, page 16)
- Helps to reduce patient and caregiver stress (Question 8, page 17)
- Enables less management of ventilation controls (Question 8, page 17)
- Supports the care giver by helping them to keep control of hectic situations (Question 8, page 17)
- Enables low sedation (Question 8, page 17 & Question 13, page 25)
- Recognizes leaks and compensates to a certain level (Question 9, page 18)

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