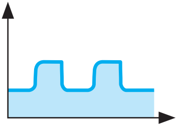
Pressure-supported spontaneous breathing

Chatburn Taxonomy: PC-CSVs
ISO 19223: CSV-PS



CSV-PS

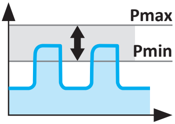
Start variable:	Trigger
Inspiratory target:	pressure support
Limit variable:	None
Cycle variable:	Endflow
Expiratory target:	PEEP
Conditional variable:	None

Dräger	GE	Getinge	Hamilton	Mindray	Löwenstein Medical
SPN-CPAP/PS	CPAP/PSV	PS	SPONT	PSV	PSV

Conventional spontaneous breathing form with adjustable pressure support. The spontaneously breathing patient's work of breathing is partially taken over or the breath deepened by setting a rigid pressure support (PS). Pressure support is initiated when the trigger criterion is reached.

Spontaneous breathing with pressure support and guaranteed volume

Chatburn Taxonomy: PC-CSVa
ISO 19223: CSV-vtPS



CSV-vtPS

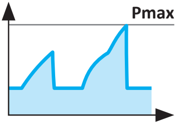
Start variable:	None
Inspiratory target:	Volume
Limit variable:	None
Cycle variable:	Endflow
Expiratory target:	PEEP
Conditional variable:	None

Dräger	GE	Getinge	Hamilton	Mindray	Löwenstein Medical
SPN-CPAP/VS	VS	VS	VS	–	Dynamic PSV

A technological advancement over conventional PSV. The spontaneously breathing patient's work of breathing is is partially taken over by dynamic pressure support (breath-by-breath adjustment of pressure support depending on the set target volume) or the breath is deepened. In each case, the effective pressure support depends on the set target volume (Vt), the patient's work of breathing and the respective overall compliance. Within a safe window (Pmax and Pmin), the required pressure support adjusts automatically on a breath-by-breath basis at increments not exceeding 3 mbar. The mode is initiated when the trigger criterion is reached. Although inspiration is determined by the patient, the timing of expiration is determined by the ventilator (PSV Endflow).

Spontaneous breathing with proportional pressure support

Chatburn Taxonomy: PC-CSVr
ISO 19223: CSV-ES[*q*+*v*]



CSV-ES[*q*+*v*]

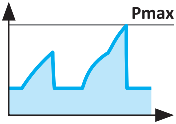
Start variable:	Spontaneous breathing
Inspiratory target:	Proportional pressure support
Limit variable:	None
Cycle variable:	Endflow
Expiratory target:	PEEP
Conditional variable:	None

Dräger	GE	Getinge	Hamilton	Mindray	Löwenstein Medical
SPN-PPS	–	–	–	–	Proportional PSV

A technological advancement over conventional PSV. The spontaneously breathing patient's work of breathing is partially taken over or the breath is deepened by proportional pressure support depending on the set degree of compensation for the flow resistances (Flow Support) and airway resistances (Volume Support). The effective pressure support varies on a breath-by-breath basis depending on the generated flow and inspired volume. For safety reasons, both the upper pressure limit (Pmax) and the apnoea ventilation must be set.

Spontaneous breathing with proportional pressure support and regular measurement of the work of breathing

Chatburn Taxonomy: PC-CSVr
ISO 19223: CSV-ES[*q*+*v*]



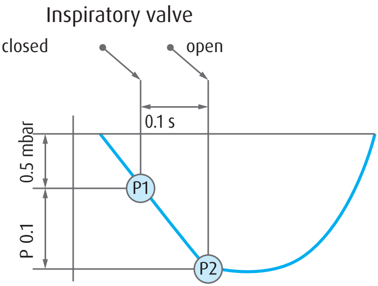
CSV-ES[*q*+*v*]

Start variable:	Spontaneous breathing
Inspiratory target:	Proportional pressure support
Limit variable:	None
Cycle variable:	Endflow
Expiratory target:	PEEP
Conditional variable:	Spontaneous breathing

Dräger	GE	Getinge	Hamilton	Mindray	Löwenstein Medical
–	–	–	–	–	PAPS

In contrast to fixed pressure support in pressure-supported ventilation, the spontaneously breathing patient receives proportional pressure support under Proportional Adaptive Pressure Support (PAPS). The effective pressure support in this mode adapts to the elevated elastic and restrictive resistances. Tyler (1962) and M. Younes (from 1987) in Winnipeg established the fundamentals of this ventilation mode. With PAPS, a special algorithm determines the current work of breathing on a breath-by-breath basis through increased flow and airway resistances and regulates selective pressure support to compensate. Depending on the manufacturer, details of the algorithm may differ, especially with regard to the determination of compliance and resistance under spontaneous breathing.

Occlusion pressure measurement: P0.1



Occlusion pressure P0.1 is a measure of central respiratory drive under spontaneous breathing. The standard range is between approx. 1.5 and 4.5 mbar. Values below 1.5 mbar indicate a low respiratory drive, e.g. due to oversedation or pressure support which is set too high. Values above 4.5 mbar indicate an increased respiratory drive; in this case adjusted sedation or increased pressure support should be considered.
As a manoeuvre under spontaneous breathing, the P.01 measurement indicates the negative differential pressure (P2-P1) measured against a closed valve in the first 0.1 seconds.

Specified as an absolute value:
1 – 4.5 mbar: Normal value
6 mbar: Risk of exhaustion due to high respiratory effort (weaning failure)

Specified as relative value:
Increase by > 4 mbar during the course of spontaneous breathing:
Risk of exhaustion

Rapid Shallow Breathing Index: RSBI

$$\frac{\text{Respiratory rate /min}}{\text{Respiratory volume (l)}}$$

The RSB index (RSBI) is a weaning indicator that can be used to try to predict the success of a weaning attempt. It is calculated from the quotient of the spontaneous respiratory rate per minute and the measured tidal volume (in litres).

Examples:

f = 25 Vt = 0.25 → RSBI = 100

f = 30 Vt = 0.35 → RSBI = 85.7

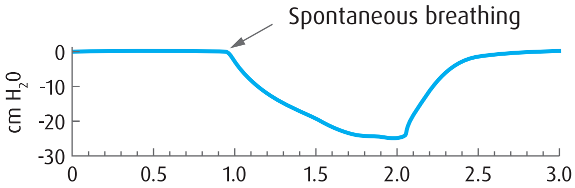
f = 30 Vt = 0.25 → RSBI = 120

The greater the calculated RSBI during spontaneous breathing of the patient, the less likely successful weaning would be:

RSBI < 100 : Probable successful weaning

RSBI > 105 : Improbable successful weaning

Maximum Inspiratory Pressure: MIP

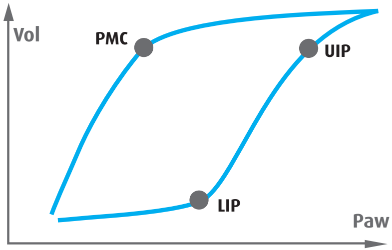


Another weaning indicator is the MIP (Maximum Inspiratory Pressure) manoeuvre, which provides information about the current maximum peripheral respiratory muscle strength. This is often referred to as the Negative Inspiratory Force Index (NIF).

Under MIP, the maximum inspiratory effort under closed valves is measured after a prolonged expiration (expiratory hold manoeuvre). Although the measurement value is controversial, it is used in particular for neuromuscular diseases.

< 20 mbar: Improbable successful weaning
> 20 mbar: Probable successful weaning

PEEPfinder manoeuvre with inflection points: LIP / UIP / PMC



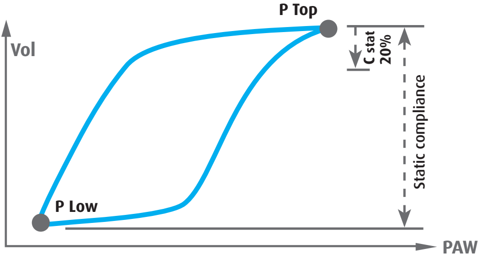
By means of a low-flow manoeuvre, the respiratory mechanical situation of the lungs can be mapped as a pressure-volume graph, whereby the following inflection points can usually be determined:

LIP: Lower inflection point	Beginning of the maximum slope of the inspiratory pressure-volume graph (compliance is highest from this pressure onwards)
UIP: Upper inflection point	End of the maximum slope of the inspiratory pressure-volume graph (compliance is reduced from this pressure onwards)
PMC: Point of maximum curvature	Point of maximum curvature of the expiratory pressure-volume graph (if this pressure is set as PEEP, the achieved lung recruitment is usually largely maintained)

Possible application:

PEEP setting based on the lower inflection point LIP	**LIP** = necessary PEEP = LIP +2 mbar
Limitation of the plateau pressure or the maximum inspiratory pressure based on the UIP	**UIP** = maximum plateau pressure or maximum inspiratory pressure
PEEP setting based on the maximum inflection point: PMC	**PMC** = PEEP

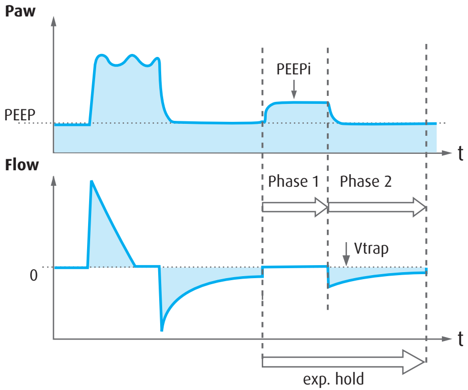
C20/C Index



The index C20/C is calculated based on the individual measurements of the PEEPfinder.

This "over-distension index" is calculated during inspiration and results from the compliance ratio of the last 20 % of static compliance to the measured compliance between P Low and P Top.
If the index is below 0.8, it may be indicative of lung over-distension.

Intrinsic PEEP: PEEPi



Independent of the adjustable PEEP level, a functional PEEP can also be effective, which is caused by incomplete exhalation.
With a multilevel PEEPi measurement in an extended expiratory time, the functional PEEP, often referred to as auto-PEEP, can be measured and the "trapped" volume determined as the trapping volume. **This manoeuvre only works reliably under controlled ventilation (passive patient)**.

Specified as an absolute value:

- Location of intrinsic PEEP and trapping volume
- Indicator on overall PEEP

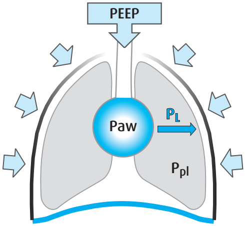
Specified as relative value:

- Effects on PEEP and trapping volume when adjusting respiratory rate, inspiratory time or inspiration/expiration ratio

End-expiratory transpulmonary pressure: TPP exp
End-inspiratory transpulmonary pressure: TPP insp

Positive transpulmonary pressure (difference between alveolar pressure and pleural pressure) is necessary to avoid alveolar collapse.
As a surrogate parameter for pleural pressure, oesophageal pressure can be measured with a modified gastric tube (PESO balloon catheter) and used to calculate transpulmonary pressure.

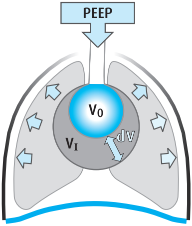
The end-expiratory transpulmonary pressure **TPP esp** (corresponding to the difference between end-expiratory alveolar pressure and pleural pressure) can be influenced by the titration of the applied PEEP.
If PEEP is adjusted to result in an end-expiratory transpulmonary pressure in the positive range (e.g. between 0 and 10 cmH_2O), this may help to reduce cyclic alveolar collapse.



TPP_{exp} = PEEP - Pes

$TPP_{exp} \approx$ alveolar collapse

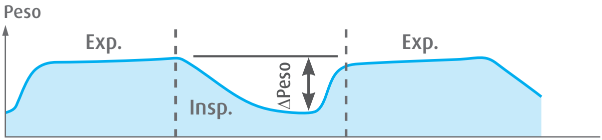
The end-inspiratory transpulmonary pressure **TPP insp** (plateau pressure - pleural pressure) reflects pulmonary distension at the end of inspiration. The TPP insp should usually be kept below 20 cmH_2O.
The pressure difference between end-inspiratory and end-expiratory transpulmonary pressure (transpulmonary driving pressure = TPP insp – TPP exp) should be below 12 cmH_2O if possible.



TPP_{insp} = Plateau - Pes

$TPP_{insp} \approx$ distension

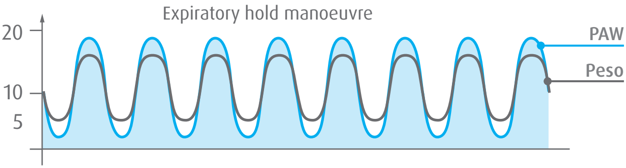
Oesophageal pressure amplitude: ΔPeso



Inadequate relief of the diaphragm muscles under spontaneous breathing can cause ventilator-induced diaphragmatic myotrauma. The bedside indicator of increased respiratory muscle effort under spontaneous breathing is the amplitude of the oesophageal pressure (ΔPeso).

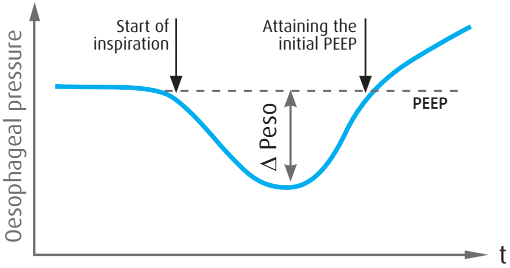
Orientation values ΔPeso:
4 – 8 mbar: Standard values
12 mbar: inadequate spontaneous breathing

Baydur Test: ΔPes/ΔPaw



Under present spontaneous breathing, the recommended test to check the Peso measurement is to compare the simultaneous negative deflections of airway and oesophageal pressures during an end-expiratory occlusion manoeuvre (the so-called Baydur test).
During occluded inspiration, the pressure changes in the airways (ΔPaw) and oesophagus (ΔPes) should be almost identical because the lung volume does not change. The peso measurement is considered reliable if the ΔPes/ΔPaw ratio is between 0.8 and 1.2. If not, the catheter must be repositioned and/or the balloon volume checked again.

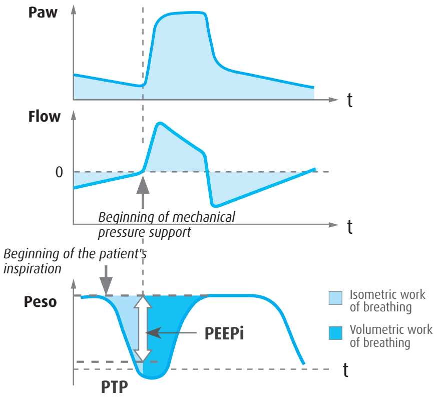
Pressure Time Product: PTP



By measuring the oesophageal pressure, the respiratory effort of the spontaneously breathing patient can be quantified, allowing for the individual adjustment of the degree of relief of respiratory effort. This allows the detection of increased respiratory muscle effort with the risk of respiratory exhaustion and can subsequently minimise the risk of weaning failure. The inspiratory work of breathing can be evaluated as an area integral over time (PTP = pressure-time product). The Pressure Time Product is considered an effective method for assessing the energy expenditure (force x displacement) of the respiratory muscles. In a spontaneously breathing patient, the work done by the respiratory muscles is equal to the integral of the product of P_{mus} and the change in volume.
There is usually a close correlation between the WOB and PTP.

Normal range: 50 – 150 cm H_2O*s
> 200 cm H_2O*s: Risk of weaning failure

Intrinsic PEEP measurement in spontaneously breathing patients



In contrast to the PEEPi measurement in a prolonged expiratory hold manoeuvre, the intrinsic PEEP can also be continuously recorded under spontaneous breathing if the oesophageal pressure measurement catheter is correctly positioned. This enables, for example, a PEEP adjustment with the aim of minimising the intrinsic PEEP.

The flow-independent drop in oesophageal pressure is measured at the beginning of inspiration. This is considered a surrogate parameter for the functional PEEP and can also be used to calculate the trapping volume.

Specified as an absolute value:

- Location of the intrinsic PEEP
- Indicator on overall PEEP

Specified as relative value:

- Effects on PEEP when adjusting respiratory rate, inspiratory time or inspiration/expiration ratio