Ventilation Measured Values

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25.1 Measured Values

25.1.1 Pressure Values

■ **Peak Pressure**

This is the maximum air pressure measured during a breathing cycle, also called pressure peak (**P_{peak}**) or PIP (Peak Inspiration Pressure). As a rule, this should correspond to the **P_{insp}** during pressure-controlled ventilation and to the **PEEP** plus **PS** during PSV ventilation. However, there are always small deviations, which are not dangerous for the patient.

■ **Minimum Pressure**

The minimum air pressure measured during a breathing cycle, also called "pressure minimum" (**P_{min}**). As a rule, this should correspond to the **PEEP** during ventilation. However, there are always small deviations, which occur especially at the onset of spontaneous breathing. The contraction of the respiratory muscles during spontaneous breathing and triggering causes a brief drop in pressure even below the PEEP level. This value is then measured and displayed (◘ Fig. 25.1).

■ **PEEP**

The "PEEP", the positive air pressure at the end of the exhalation phase (expiration phase), checks whether the set PEEP corresponds to the measured PEEP. Mostly it matches, sometimes there are small deviations that are not dangerous for the patient.

■ **Respiratory Fluid Pressure**

The ventilator calculates the respiratory medium **pressure**, or "pressure mean**" (P_{mean}),** for each breathing cycle. It is the mean value of the peak pressure **P_{peak} /P_{insp}** and the PEEP.

■ **Example**

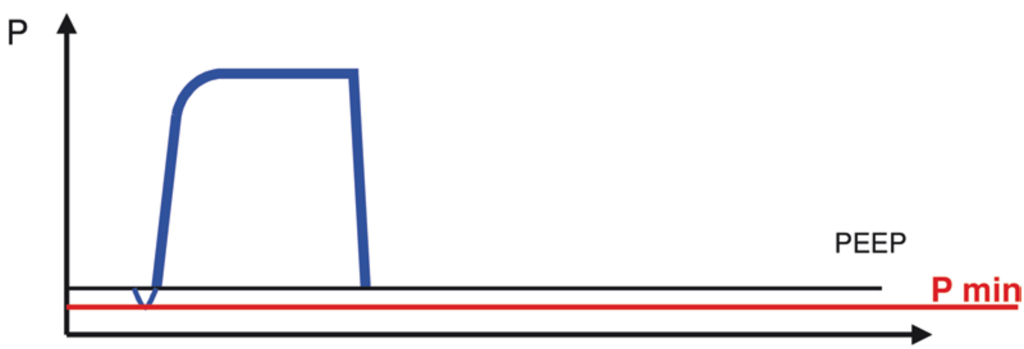
P_{insp} = 20 mbar

PEEP = 8 mbar

Calculation of the mean value: 20 + 8 = 28:2 = 14 mbar.

In the ventilation of adults, this measured value has a subordinate role. While it is of great importance in the ventilation of premature and newborn infants and provides information on whether the airways remain open during the entire respiratory cycle.

- The higher the mean pressure, the more likely it is that the airways will remain open.
- The lower the mean pressure, the greater the risk of respiratory collapse.



◘ **Fig. 25.1** P_{min} with triggering (Own display, edited by Isabel Guckes)

25.1.2 Volumes

Respiratory Minute Volume

The ventilation or breathing volume that reaches the patient's lungs within 1 min is also called **MV**. It is calculated from the respiratory volume ($V_{t)}$ × respiratory rate (***f*****/AF**).

Spontaneous Respiratory Minute Volume

This is the MV inhaled through spontaneous breathing (**MV spontaneous**). Many forms of breathing allow spontaneous breathing, such as PS or AVAPS. The proportion of the total MV is measured as described above. The proportion of MV achieved by spontaneous breathing activity is shown separately in the measured values. In the case of augmented ventilation modes, there are indications of how large the proportion of spontaneous breathing currently is.

Inspiratory Volume

The respiratory volume (**AZV**) or tidal volume "volume tidal" (**V_t or $V_{ti)}$** measures how many milliliters (ml) of air enters the patient during inspiration. The patient should receive an appropriate volume of air per breath. In pressure-controlled and pressure-regulated ventilation, this is achieved indirectly by the difference between P_{insp} and PEEP. In volume-controlled ventilation, the set volume should correspond to the measured inspiratory volume. In PSV ventilation, a corresponding V_t is achieved indirectly by the difference between PS and PEEP.

Expiratory Volume

The volume tidal expiration (**$V_{te)}$** indicates how many millilitres (ml) of air comes out of the patient's lungs during expiration. There will be variations between V_t and V_{te}. These deviations occur rather rarely during controlled ventilation and are small. However, greater deviations may occur during spontaneous breathing. Inhaled and exhaled air volumes do not always correspond in one breathing cycle. In the course of a minute, however, they usually balance out.

Caution is required if the inhaled (inspired) air volume is always greater than the exhaled (expired) air volume. This can lead to unwanted air accumulation in the lungs, which increases the air pressure inside the lungs. This contributes to the development of "intrinsic PEEP". This would then also increase the PEEP and pmean readings (► Sect. 25.1.1).

> The V_{te} is only measured if a two-hose system is used.

25.1.3 Frequency Values

Ventilation Frequency

The ventilation frequency, ***f*$_{mand}$** or **AF$_{mand}$** is given in "breaths per minute" (**bpm**) or AZ/min (=breathing cycles per minute). It is measured and counted how often a patient is ventilated per minute in controlled ventilation. This should correspond to the set ventilation frequency f or AF.

Spontaneous Breathing Rate

During A-PVC ventilation, a patient can trigger further ventilation strokes. The proportion of the frequency that is generated by the patient's own spontaneous breathing is indicated in the measured values (spontaneous breathing phases, ***f*$_{spontaneous}$** or **AF$_{spontaneous}$**). Only the respiratory frequency that the patient generates through spontaneous breathing or through his own breathing per minute is measured. In **pressure-supported PSV breathing**, the number of times the patient breathes on his own is measured and counted.

Respiratory Rate

For the respiratory rate (***f*** **or AF**), it is measured and counted how often a patient is ventilated per minute. Since the patient can trigger further ventilation phases in A-PCV mode and can also breathe spontaneously in PSV mode, it can happen that the measured respiratory rate is higher than the set ventilation rate. Here, mandatory and spontaneous frequency are usually added together.

25.1.4 Further Measurement Parameters

■ Breath–Time Ratio *I*:*E*

The **inspiratory–expiratory** ratio (***I***:***E*** **or** $\mathbf{T_i}$ **/** $\mathbf{T_{tot}}$) indicates the temporal relationship between the inhalation and exhalation phases. In controlled ventilation, this value is determined by the setting of ventilation rate and T_{insp}. This means that it is usually the same. However, if the patient triggers further ventilation phases, the breathing time ratio also changes. The most commonly used breathing time ratio of 1:2 will then be changed, for example 1:1.5. In PSV ventilation, the ventilator recalculates the breathing time ratio with each breath of the patient. Therefore, this value may vary considerably, for example 1:1.3 but sometimes also 2.1:1.

■■ Breath–Time Ratio $T_{i/}T_{tot}$

In this variant of measuring the breath–time ratio, the entire respiratory cycle, consisting of inspiration and expiration, is referred to as $\mathbf{T_{dead}}$ and assigned the value 100% or the integer 1. The portion used for inspiration $\mathbf{T_i}$ is therefore always only a part of the 100%, for example 30%. This value is displayed. The portion used for inspiration $\mathbf{T_i}$ is therefore always only a part of the integer 1, for example, 0.3. This value is displayed.

■ Inspiration Phase, Inspiration Time

The duration of the inhalation phase, "**time inspiration**" ($\mathbf{T_{insp}}$ or $\mathbf{T_i}$) is given in seconds. In controlled ventilation, this value is fixed, so the set value and measured value correspond. In ASB/PSV ventilation, almost every breath of the patient is different from the previous one. How long the inhalation phase lasts for the patient's spontaneous breathing is measured by the ventilator anew with each breath. Therefore, there can also be strong variations.

■ Expiration Phase, Expiration Time

The duration of the exhalation phase, "**time exspiration**" ($\mathbf{T_{exsp}}$ or $\mathbf{T_e}$) is given in seconds. This is only a measured value, as normally no predetermined expiration phase is set on the respirator. The duration of the exhalation phase results either from the settings *f* or AF and the inspiration time T_{insp} or T_i. Or it results from the setting of the respiration time ratio *I*:*E* or $T_{i/}T_{tot}$.

■ Resistance

Section ► 21.1

■ Compliance

Section ► 21.2

■ Rapid Shallow Breathing Index (Sect. ► 30.6)

The RSB or RSBI or f/V_i is displayed in spontaneous breathing mode PSV and is a quotient between spontaneous breathing rate and measured inspiratory volume. It gives an indication of the respiratory capacity (Sect. ► 2.1.1 Muscular capacity and exertion) of a patient.

- The smaller the value, the stronger the patient is.
- The higher the value, the less strength and endurance a patient has for spontaneous breathing.

> The RSBI is also displayed in A-PCV mode on the Respirator Astral (ResMed). However, the RSBI will be constant. It is only a display value which does not make any statement about the breathing capacity of the patient.

- **% Trigger**

With A-PCV it is measured how often the person triggers an additional ventilation stroke and is displayed as a % value.

- **Example**

15 ventilation cycles/min and additionally 3 triggered breathing cycles = 18 measured breathing cycles.

Then a calculation of three sets: 18 AZ = 100%.

How many % is 3 AZ then?

% trigger = 16.6%

In PSV mode, you would expect to get 100% trigger. However, if the person is exhausted and can no longer breathe independently, the back-up ventilation function is automatically activated and the person is fully ventilated. In this way, a 0% trigger can also occur in PSV mode.

- **Oxygen Concentration**

With the O_2 concentration, a comparison of the set with the real measured O_2 concentration is carried out.

> If there is a large deviation, permanently greater than 3%, there will be a fault in the respirator. The device may no longer be used and must be replaced. The technical service must be informed.

25.2 Ventilation Protocol

A ventilation log is usedfor documentation and thus for recording the measured values of the ventilation settings (◘ Fig. 25.2). Such a protocol could be supplemented by the ventilation settings specified by the ventilation center or the attending physician. The recorded measured values should also be used to assess the ventilation.

The protocol is assigned to a patient. It records which respirator he is supplied with and whether there is a second device. This is required for patients whose ventilation duration is greater than 16 h/day. The ventilation duration is documented in hours during the day and at night. In this way, it is possible to assess whether the duration changes over time. As a rule, the ventilation duration is also specified by the ventilation center or the attending physician as a medical prescription (AVO).

It is recorded with which ventilation access the patient is provided with, invasively with tracheal cannula and size of TK or non-invasively with NIV mask and size. The manufacturer of the ventilation accesses could also be listed here. The type of respiratory gas humidification is indicated, active humidification or passive humidification with an HME filter. A ventilation should always have a respiratory gas humidification. The corresponding systems have been prescribed by a doctor.

The individual measured values are written down with date and time. Not all values mentioned in ► Sect. 25.1 need to be documented. The values listed in the example are sufficient to be able to assess ventilation.

The temporal documentation interval can be arranged variably. For people whose ventilation is not stable and regular, for example in the case of fever and respiratory tract infections, a tighter time interval seems to be appropriate. The interval should depend on the patient's state of illness and can be 2 h if necessary. If ventilation is stable, documentation at each shift change will be sufficient. People's sleep should not be disturbed by over-motivated documentation. In addition, there is memory in the respirator, so that it is possible to add the measured values.

The measured values will vary, so the respective documentation is only a snapshot of the ventilation. However, if the values move within a range, the changes are not critical. This frame is also determined by the alarm limits (► Chap. 24). It is possible that a change can be observed over days, weeks or months. It is also the responsibility of

Ventilation Protocol

Name of Ventilator (Name): ______________________________

Desease of patient that leads to ventilation: ____

Ventilation-Mode the doctor or the hospital made: (please mark):

A-PCV		PSV		SIMV		AVAPS		Andere	

Ventilation-settings the doctor or the hospital made: (please fill in) :

IPAP P insp	EPAP PEEP	Frequency or Respiration Rate	T insp	I : E	Trigger (level) or declaration in l / min.	Rise time (in sec) or Ramp (level)	O2 (l / min) O2 (%)

Measured values /data (essential to be documented) :

Date	time	P peak PIP	PEEP	Frequency or Respiration Rate	Spont. Freq.	T insp T i (inspiration time)	I : E	V ti	V te

Fig. 25.2 Example of GHP Pflegedienst Hamburg and surroundings (Courtesy of GHP Pflegedienst in Hamburg and surroundings)

professional carers to determine and assess these changes. This documented information must be passed on to the treating physician.

Examples of Measured Value Changes:

- If the values deteriorate, the AZV and AMV may decrease, although the ventilation pressures have not changed. If this occurs within a short period of time (hours, days), the patient's ventilated lungs or general condition may have deteriorated acutely.
- But values could also improve. If, for example, AZV and AMV increase with constant pressure over time, this could indicate an improvement in the lungs. The physician would have to decide whether the ventilation pressures could be reduced.
- If, for example, the spontaneous breathing rate increases, this could indicate that the patient's own breathing is increasing and the patient may need fewer ventilation hours during the day. The treatment goal could even be to achieve a large degree of spontaneousization and weaning from the respirator.

Conclusion

Measured values alone provide an indication of whether ventilation is running regularly or not. Changes can be observed and interpreted. This applies to all values that are collected and documented, including pulse, RR, consciousness, etc. However, this does not replace the general observation of people by the nursing staff, but rather complements it.

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