# Secretary Management

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## Contents




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## 29.1 Ability to Cough

The ability to cough is vital. With the cough it is possible to transport secretions and foreign bodies out of the airways. The removal of secretions from the airways by coughing is called secretion clearance.

In order for a person to be able to cough, a number of conditions are necessary:

- Sufficient inspiration (at least 1.5 L of air).
- Ability to close the epiglottis (glottis closure).
- Building up sufficient pressure within the airways (high intrathoracic pressure).

### 29.1.1 Coughing Procedure

The coughing process takes place in four phases (◘ Fig. 29.1).

- Phase 1: **Inspiration phase** → deep inhalation with a pause in breathing.
- Phase 2: **Inspiratory break.**
- Phase 3: **Compression phase** → creation of a high intrathoracic pressure (compression) by pressing against the closed epiglottis (glottis closure).
- Phase 4: **Ejection phase** → abrupt opening of the epiglottis; this causes the air to flow out at a high speed (air speed approx. 360 L/min.)

For a coughing shock to be effective, a minimum air flow of 270 L/min is required. The cough becomes critical when the flow is less than 160 L/min, which would no longer guarantee effective secretion clearance.

Coughing, clearing your throat or sneezing is in principle a very quick exhalation. As a result, the secretions are carried along by the very fast exhaled air stream and are transported out of the airways. Coughing or clearing the throat occurs several times in succession, not just once.

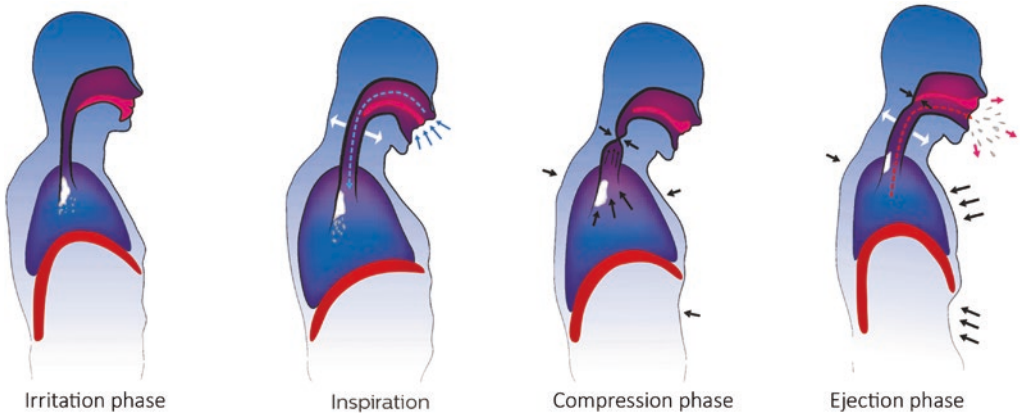
### 29.1.2 Problems with Reduced Cough

Patients with reduced coughing are particularly at risk of suffering complications. These are especially people with

- a weakened respiratory pump,
- neuromuscular diseases,
- constricted and swollen airways,
- restricted ciliary mobility or
- bronchopulmonary diseases that impede secretion clearance.

People with a **weakened respiratory pump** have the following problems, among others:

- Reduced ventilation (hypoventilation).
- This reduces the ability of the lung tissue to stretch.




◘ **Fig. 29.1** Coughing procedure (Courtesy of Philips GmbH Respironics)

- Thereby clearly weakened coughing impulse.
- Thereby reduced or lacking secretion elimination.

People with **narrowed and swollen airways**, for example in the case of COPD, also have problems with the mobilisation of secretions:
- Their secretions are very viscous.
- These are difficult to mobilize due to the narrowed airways.
- This means that they accumulate preferentially in the lowest airways.

People with **limited ciliary mobility** have problems with mobilisation of secretions:
- Mucus is still produced by the mucus-forming cells of the respiratory tract.
- However, mucus and secretions are not transported away by the cilia' flickering activity and accumulate in the lowest airways.

**Complications of a Lack of Secretion Clearance**
- Obstruction or blockage of the airways due to accumulation of secretions.
- These can affect whole lung areas, for example segmental and trunk bronchi.
- This results in reduced ventilation of these areas.
- Often there is no ventilation at all.
- A lack of ventilation leads to a lack of oxygen supply, the consequence is oxygen deficiency (hypoxia).
- Accumulations of secretions are an ideal breeding ground for pathogenic germs, the result is an infection or even pneumonia.
- Pneumonia can lead to complete respiratory failure in patients with a weakened respiratory pump.
- This often leads to invasive artificial respiration.

## 29.2 Support for Coughing

The support of the coughing process should include the inhalation phase, the inspiration pause with compression and the expulsion phase. People who cannot perform these phases alone due to muscular weakness require both manual and technical assistance. These aids are effective if they are applied 2–5 times in a row and not just once.

### 29.2.1 Measures to Increase the Intrathoracic Volume

The measures to increase the inhalation volume in preparation for coughing can be carried out manually or with technical aids. The aim of all measures is to achieve a sufficient inspiratory volume (Phases 1 and 2) and that the air is then held and compressed intrathoracally (Phase 3).

To mobilize mucus, air must be present distally (behind) the obstruction (mucus) (◘ Fig. 29.2). Only then can the secretion be transported by the outflowing air or by the increase in pressure behind the obstruction ("air behind the plug").

In order for the air to pass behind the constricting mucus plug in the inhalation phase, it should flow slowly. For machine ventilation, this means that the inspiratory flow must be slow, approxImately 25–30 L/min or 0.3–0.5 L/s.

During regular ventilation, flow rates of 40–80 L/min or 0.6–1.2 L/s are achieved. This would transport the secretion plugs further into the bronchial system (◘ Fig. 29.3). Mobilization to the outside is thus more difficult.

**Manual Measures**
- **Mobilisation**: mobilisation means increased physical effort and causes an increased depth of inhalation. This is not hindered, but allowed even in artificial ventilation with the ventilation modes A-PCV and PSV.

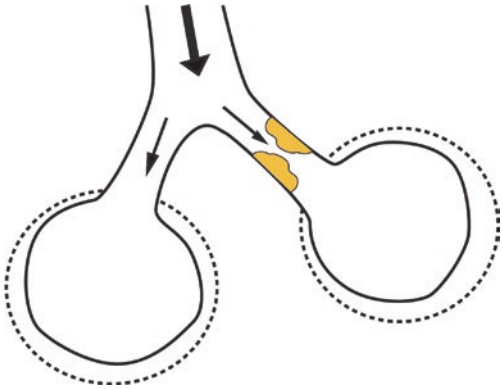


**Fig. 29.2** Slow and steady inspiration (Own representation, edited by Isabel Gucke's)

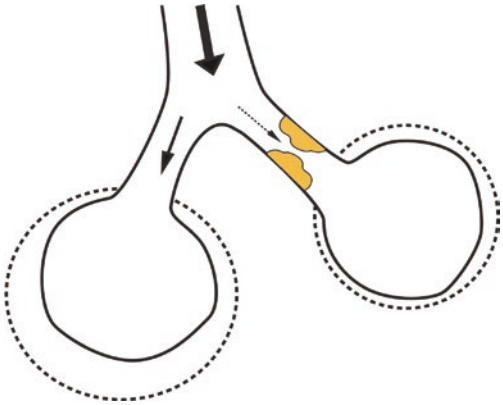


**Fig. 29.3** Quick inspiration (Own representation, edited by Isabel Schlütter)



- **Contact exercises:** here, a therapist or a nurse places his hand on a region of the lung, for example left dorso-lateral (facing the back, outside back). This hand contact is intended to ensure that the air is directed to the lung regions during the inhalation phase. However, the patient must concentrate on this, which will be difficult with artificial respiration. People who breathe spontaneously can do this well under guidance.
- **Packing and stimulating handles**: the purpose of this breathing exercise is to consciously direct the breath into a region of the lungs. This therapeutic measure also works with artificially ventilated people. The pack and stimulus grips are applied by the therapist during the inspiration phase (Fig. 29.4). Skin contact is maintained during the expiration phase.
  - These grips are also used to reduce tissue resistance, for general relaxation and, in people who breathe spontaneously, they can reduce the breathing rate.

Caution, these exercises may be painful as skin folds are "grabbed" and pulled. People with sensitive skin should not undergo these breathing exercises.

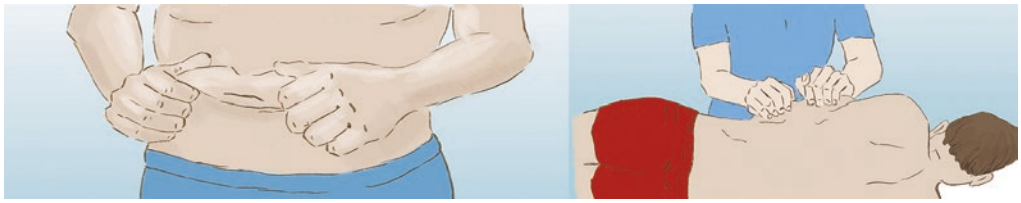


**Fig. 29.4** Packing and stimulus handles (Own representation, edited by Isabel Schlütter)

## Mechanical Support Measures

All measures serve to increase the depth of inhalation as preparation for coughing. It is hoped that the large amount of inhaled air will be expelled from the lungs at an increased speed and bronchial secretions will be carried out. As a further effect of these measures, the lung is recruited, that is unventilated lung areas are reopened and thus recovered for gas exchange.

- **Air Stacking with Ambu Bag**

The person is carefully over-inflated with the help of an Ambu bag. This is possible with tracheotomized and also with spontaneously breathing people. As a rule of thumb, how much volume should be allowed to enter the lungs can be taken as twice to three times the normal breathing volume. An Ambu bag for adults has a possible filling volume of 1.5–1.7 L.

Once the lungs are filled with the increased volume, the elastic properties of the thorax and lungs are used. The Ambu bag is removed and the air flows out of the lungs at a higher speed. Due to the increased exhalation speed, bronchial secretions should be transported out with it.

The process can be repeated up to five times, several times a day and if necessary at night.

- **LIAM for Ventilogic Respirators**

The **Lung Insufflation Assist Maneuver** (LIAM) of the Ventilogic respirators (Weinmann company) also follows the principle of cautious over-inflation of the lungs. However, a predetermined air pressure is set which is approximately twice the ventilation pressure that would otherwise be set. This over-inflation maneuver is triggered by pressing the so-called LIAM button on the ventilator.

The setting of the pressure level is done by the ventilation center, which also determines how often the maneuver is performed. Usually, it is performed 3–5 times a day, if necessary also at night.

- **VCV**

Volume-controlled ventilation (VCV) can be set as the second mode in many ventilators. In this mode, the patient's lung is carefully over-inflated with a predetermined breathing volume, and usually twice or three times the breathing volume otherwise administered. Here too, the setting is made by the ventilation center.

## 29.2.2 Measures for Intensified Expiratory Air Flow

## Manual Cough Support

If the expiratory force is insufficient, the expiratory flow can be increased synchronously with the cough by using sheets or cloths wrapped around the patient's trunk. If the patient does not tolerate this measure, manual support can also be provided by a light handshake in the epigastrium. With manual support measures, care must be taken to ensure that the pressure is mainly applied to the abdomen and that the pressure is applied synchronously with the cough (◘ Fig. 29.5).

## Mechanical Cough Support

- **Cough Assist devices (◘ Fig. 29.6)**

**Deployment**

A cough assistant device is a mechanical in- and exsufflator that simulates a natural cough. For this purpose, during inhalation—similar to normal deep breathing—a large amount of air is gradually released into the respiratory tract (positive pressure) and then switched to negative pressure so that secretion deposits are transported out of the lungs (negative pressure/suction). A coughing cycle is imitated. As a rule, 3–6 cough cycles are used, as with the normal cough. These form a coughing sequence.

**Indications**

The in- and exsufflator is suitable for patients who have no or only an insufficient

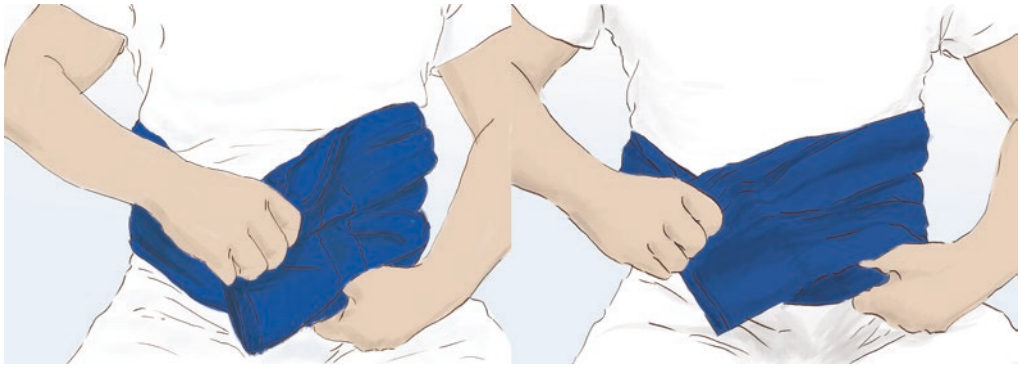


**Fig. 29.5** Manual expiratory aid (Own representation, edited by Isabel Schlütter)



**Fig. 29.6** Cough Assist (Courtesy of Phillips Respironics)

cough. These are usually patients with neuromuscular diseases, injuries of the spinal cord, but also with caution and restrictions, also in COPD. The procedure is also suitable for acute infections of the respiratory tract if other air stacking measures (air stacking ► Sect. 29.2.1) are not sufficient and to reduce the invasive suctioning of secretions.

**Contraindications**

- Secured bullous emphysema.
- Known susceptibility to pneumothorax or pneumomediastinum.
- Severe heart disease.
- Fresh operations on thorax or lungs.
- Fresh abdominal operations.
- Condition after barotrauma.

### Basic Application Principle of Cough Assist

The Cough Assist can be applied with the help of a face mask, a mouthpiece or a tracheal cannula. If possible, patients should sit upright during treatment. For tracheal cannulas, the pressure of the cuff can be increased.

The ventilation center determines which application method is to be used, how high the insufflation pressure is to be built up and how long a pause phase should last before exsufflation, suction (the PEF—Peak Exspiratory Flow) is generated. The application can be manual or automatic:

- When used manually, the coughing cycle is started by a switch or foot pedal. The manual procedure is suitable for patients

with a preserved cough drive, so the beginning and the course of the cough cycle can be discussed with the patient. The pause time and exsufflation are also performed manually.
- For automatic application, in addition to the above parameters, the duration of the insufflation, pause and exsufflation phases is defined. These values are then shown on the Cough-Assist display. An extended application of the automatic function is triggering, that is patients can trigger the sequences when they are ready for them. However, patients without their own respiratory drive cannot use this function.

## 29.3 Endobronchial/Endotracheal Suction

Normally, it is possible to cough up and expectorate secretions that accumulate in the respiratory tract. The mechanisms as described in the chapter "Respiratory gas humidification" can help here. Intubated and ventilated patients do not have the possibility of coughing up. The elimination of secretions is not possible for them. Although it is desired that their cough reflex is maintained, they need help to expel the secretions.

**Reasons for Extraction:**
- Maintaining the patency of the tracheal cannula.
- Avoid laying due to secretions.
- Reduced cough reflexes in case of too deep sedation or coma.
- Tough mucus with exsiccosis.
- Preventing infections.

**Basic Procedure:**
- Informing patients.
- Keep the procedure as short as possible, max. 20 s, otherwise there is a risk of hypoxia.

**Preparation:**
- Position patients so that the tracheal cannula can be easily reached; this does not have to be the supine position. Suction can also be performed in the lateral or prone position
- Meanwhile, turn on suction and attach suction catheter.
- Use suction catheters that are as "atraumatic" as possible; they do not adhere to the mucous membranes, but form an air cushion during suction, which protects the tissue.
- Put on gloves, face mask and safety goggles.
- Put on sterile gloves.

**Implementation:**
- Disconnect patient from the ventilator → place "goose gargle"/connector on a sterile surface (the inside of the sterile glove packaging is suitable for this purpose).
- Grasp the sterile suction catheter with a sterile glove.
- Hold and fix the tube with your unsterile hand all the time, the suction is also activated with your unsterile hand → so hold the suction hose firmly.
- Use your sterile hand to insert the sterile suction catheter into the tube.
- Insert the suction catheter without suction.
- Atraumatic suction catheters must be inserted with suction!
- Insert until resistance is encountered.
- Do not overcome the resistance with force → in this case do not insert the suction catheter any further!
- Insertion with rotating movement of the catheter can overcome resistance.
- Slowly pull out with suction.
- Pull out the suction catheter with rotating movements.
- No "poke", no sudden movements!

- If necessary, repeat the procedure if secretion is still present.
- Then reconnect the "goose gargle"/connector to the tracheal cannula.
- Final check of the cuff pressure and position of the tracheal cannula.

**Important to Note:**
- There may be tracheal lesions of the inner wall → risk of bleeding.
- The suction catheter may injure the carina → risk of bleeding.
- So-called atraumatic suction catheters are often recommended.
- The risk of bleeding is higher the more anticoagulants the patient receives.
- Danger: due to the bleeding and seepage of blood, the tube, trachea and bronchial tubes can be repositioned
- Have an Ambu bag ready, if necessary use it for positive pressure ventilation.
- Then reconnect the patient to the respirator.
- Observe respirator → is sufficient volume administered?

Under pressure-controlled ventilation (PCV), it is quite possible that pressure is built up but no volume is delivered.
- →Note on airway obstruction.
- →Reference to bronchospasticity.

Modern respirators then also give an "apnea alarm", because no air flows within the tube system. Therefore no breathing cycle can be registered. The display "*f*" (frequency) therefore also decreases until the apnea alarm is triggered. As a rule, backup ventilation will then take over. If the volume is insufficient, the ventilator will also administer the safety $V_t$. During this period, the ventilation pressure will increase (see ► Sect. 9.5).

**Important to Note:**
- The probability that the right main bronchus is more likely to be aspirated, as it falls more steeply than the left
- Vagus stimulus can be triggered → bradycardia and RR drop.
- Sympathetic stimulus can be triggered → tachycardia and RR increase.
- Therefore observe pulse oximetry during aspiration.
- If the stimuli are triggered, stop aspiration immediately, usually the bradycardia will also stop.
- Continuous monitoring of oxygen saturation before, during and after aspiration.
- Other dangers of endobronchial suctioning: Alveolar collapse and new formation of atelectases.
- Evaluation and documentation of the secretions according to composition, consistency, smell and colour.

### Insertion Depth of the Suction Catheter

Due to the risks involved, the suction catheter should only be inserted deeper by trained and experienced nursing staff. These are summarized once again in the overview:

**Risks During Suctioning**
- Suction of the catheter at the bronchial wall
  - → thereby injuries or lesions on the bronchial wall
- Irritation of the carina
  - → thereby triggering a very strong cough stimulus
- Injury of the carina
  - → thereby lesions up to necroses at the carina
- Triggering of bradycardia or tachycardia, drop in oxygen saturation
  - → thereby risk of hypoxia

If these risks become more frequent during the suction procedure or are constantly present, the suction catheter should only be inserted as deep as the shaft of the tracheal cannula is long.

- **Subsequent Oral and Nasal Care**

- In addition to endotracheal suction, oral and nasal care should be performed in one step. Here too, all secretions are aspirated orally and nasally. They are assessed according to their consistency, consistency, odour and colour.
- Secretions of the nasopharynx always represent a reservoir for germs. They form a moist chamber, the environment in which pathogenic germs grow. Accumulated secretions in the nasopharynx hold the danger of silent aspiration.
- It is obligatory to remove bark, food remains, coatings, etc. from the oral cavity, to cleanse the nose of scabs and dried secretions or blood, and to subsequently care for the skin of the nasal mucosa and lips.

### 29.3.1 Closed Versus Open Suction

Discussions on the various advantages and disadvantages of closed versus open suction are still ongoing. These relate, among other things, to the rate of pneumonia or its reduction, change intervals, PEEP and monitoring losses and manageability.

In general, closed suction systems are recommended for

- High oxygen supply, $O_2$ concentration >50%.
- PEEP >8 mbar.
- Patients with problem germs (MRSA, AIDS, Tb, 3 or 4 MRGN).
- Prevention of cross-infections.
- Infection prophylaxis.

With regard to the pneumonia rate, neither the open nor the closed suction system could bring about a significant reduction.

One problem of closed suction systems is the accumulation of water in the plastic sleeve, which forms damp chambers and thus reservoirs for germs. Closed suction catheters are rapidly microbially colonised at the tip. The germs are reintroduced into the respiratory tract during each suction procedure. A change interval of 24–48 h is therefore recommended. The problem with open suction systems is the disconnection of the ventilation tube from the tube. This increases the risk of germ migration.

Disconnecting also often results in the personnel being exposed to a wet and humid air stream. This wet and humid air stream, which can also be contaminated with germs, is then poured onto their hands and onto the upper body of the patient.

A further problem of disconnection is the loss of PEEP, which can lead to the formation of new atelectases, which only have to be reopened with the reconnection. This impairs oxygenation. Although a negative pressure is automatically generated by the closed suction, the PEEP is at least regionally suctioned. However, closed suction prevents a general loss of PEEP. Ventilation is not interrupted. Disconnections cause a loss of monitoring: there is no monitoring of respiratory rate and volume by the ventilator.

Opinions are likely to be divided on manageability. In closed systems, it is often complained that suction cannot be performed so effectively because the catheter is only inserted rigidly. In addition, there is a lack of tactile sensitivity through the plastic sleeve. However, these concerns should diminish with increasing practice and familiarity (◘ Fig. 29.7).

### 29.3.2 Subglottic Suction

Subglottic suction is used to aspirate secretions that pass through the larynx and glottis and onto the cuff (► Sect. 4.3.2). Through a small suction tube inserted in the cannula shaft, the secretions that lie on the cuff can be specifically aspirated. The suction can be done with the help of a syringe or a suction device (◘ Figs. 29.8 and 29.9).

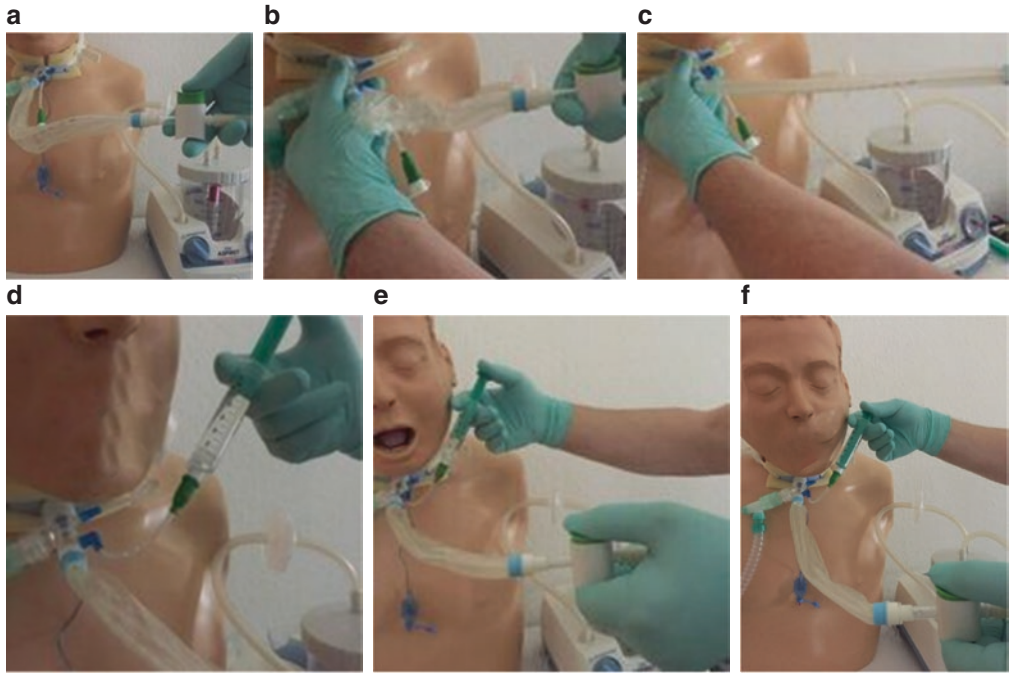



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**Fig. 29.7** Closed suction

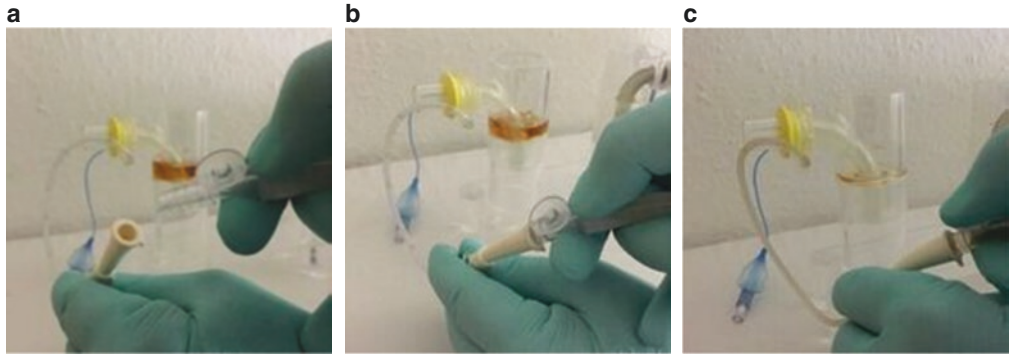



**Fig. 29.8** Subglottic suction with suction unit

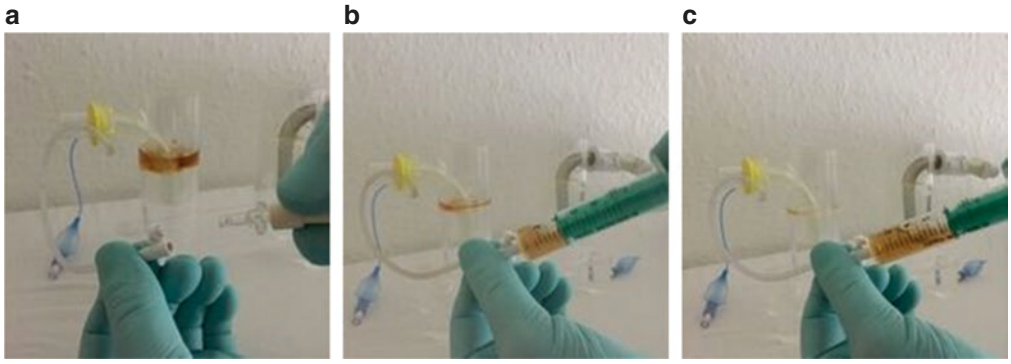



**Fig. 29.9** Subglottic suction manual with syringe

The suction with a syringe is always intermittent. The suction with suction device can be done intermittently or continuously.

## 29.4 Inhalation Therapy

Advantages of inhalation therapy compared to systemic application:

- High local concentration of active ingredients.
- Low total dose.
- Favourable effect—side effect ratio.
- Rapid onset of effect.

Table 29.1 gives an overview of the average particle size that can be inhaled.

In a therapeutic inhalation, the inhaled particles should be directed to the place where they can also develop their effect. For this purpose, the respiratory tract is roughly divided up to simplify matters (Table 29.2 and Fig. 29.10). Particles that are to be inhaled specifically must be small, the smaller the distance to the airways.

Particles to be therapeutically inhaled have a size of 2–6 µm. The optimal particle size is 3 µm in the middle. Oscillating diaphragm and nozzle nebulizers produce 3–6 µm. Non-ventilated, unventilated lung areas cannot be reached by inhalation, for example atelectasis, emphysema, cystic fibrosis.

### 29.4.1 Deposition

The deposition or separation of an inhaled active substance, an inhaled aerosol, in the respiratory tract is called deposition. The deposition is dependent on:

- Particle size (the place of separation).
- The breath volume, the inspired air volume.
- The respiratory flow, the inhalation velocity.
- Airway geometry and morphology.
- Influence of the breathing volume.
- The deeper the breath, the more aerosol is inhaled.
- With deep breathing the functional dead space has less effect (oral cavity, hypopharynx, trachea = 150 mL).
- The deeper and slower the inhalation, the more active substance is deposited.

**Table 29.1** Average particle size

| | |
|---|---|
| Gas molecules | 0.001–0.01 µm (µm = micron) |
| Viruses | 0.005–0.05 µm |
| Soot/tobacco smoke | 0,01–0,5 µm |
| Bacteria | 0.5–15 µm |
| Pollen | 3–15 µm |
| Fog | 4–100 µm |

**Table 29.2** Respiratory tract inhalation sites

| Airways | Where | Particle size |
|---|---|---|
| Central | Trachea, truncal bronchi | 5–10 µm |
| Intermedial | Bronchia | 3–5 µm |
| Peripherals | Bronchioles and alveoli | 0.5–3 µm |



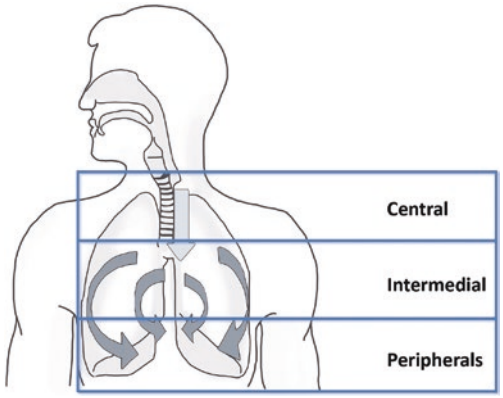



**Fig. 29.10** Deposition sites (Own representation, edited by Isabel Schlütter)

Influence of the respiratory flow:
- Slowly inhaled particle follows the respiratory tract.
- Particle inhaled too quickly already hits proximal airway walls.
- At a respiratory flow of 30 L/min particles <2–3 µm reach the deep respiratory tract.

## 29.4.2 Types of Deposition

### Impaction

Is the deposition of particles/aerosols on curves and curvatures of the respiratory tract. This deposition depends on the inertia, that is the size and weight of the particle. Due to their inertia, the particles take a straight path and do not follow the inspiratory airflow. Particle size >10 µm.

### Sedimentation

Is the deposition of particles/aerosols on the mucous membrane following gravity. This deposition depends on the particle size and the residence time in the large and middle airways. The particles follow the inspiratory airflow. The slower and deeper the inhalation, the better the deposition. Particle size 3–10 µm.

### Diffusion

Is the deposition of particles/aerosols on the bronchial or alveolar wall. It increases if the particle remains on the wall for a long time. The particles follow the "Brown molecular movement". They virtually float in the air. Particle size <0.5 µm.

Systems of inhalation therapy
- Dosing aerosols.
- Nebulizer:
  - Nozzle nebulizer (Pari Boy®).
  - Ultrasonic nebulizer.
  - Vibrating diaphragm nebulizer (Aeroneb Pro®).

### 29.4.3 Metered Dose Inhalers

Propellant-driven metered dose inhalers, so-called MDIs. The active ingredient is in suspension or as a solution in a propellant. The active ingredient is released when the propellant evaporates.

**Inhalation Technologuy with Metered Dose Inhaler Sol (DA):**

- Cap off, mouthpiece down.
- Shake (except solution DA).
- Breathe out deeply.
- Firmly enclose mouthpiece.
- Breathe in slowly, triggering.
- 3–5, better hold air for 10 s.
- Exhale through nose.
- Put on cap.

Die Deutsche Atemwegsliga (The German Respiratory League) has published various videos that illustrate the correct use of the various inhalation systems and techniques. Here, the internet address: ► https://www.youtube.com/results?search_query=deutsche±atemwegsliga

#### Application of a Metered Dose Aerosol During Tracheotomy or Machine Ventilation

There are several options for the administration of MDIs. Various adapters are available for this purpose, which are shown in Figs. 29.11, 29.12, 29.13, 29.14, 29.15. They ensure that the inhalate can be safely administered into the airways through the tracheal cannula. However, a slight loss of the active ingredient quantity must be expected.

The MDI should be triggered synchronously with inspiration. People with spontaneous breathing should be encouraged to deepen their inhalation and, if they have the capacity, hold their breath a little.

#### Application with Closed Suction

Machine ventilated people also receive the DA synchronously with inspiration. However, the ventilation rhythm is fixed.

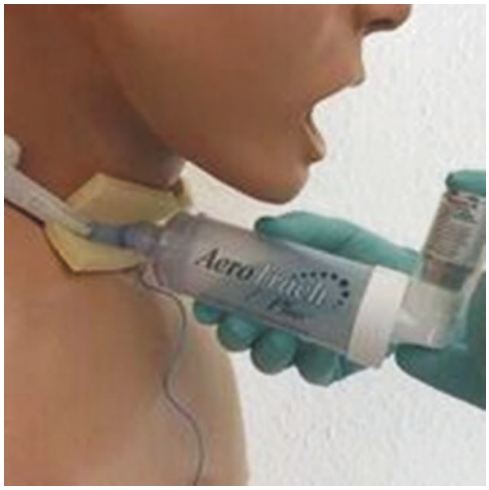



**Fig. 29.11** Inhalation with Aero-Trach (Courtesy of Trudell Medical)

**Fig. 29.12** Adapter for dosing aerosol (e.g., with kind permission of the company Medisize)

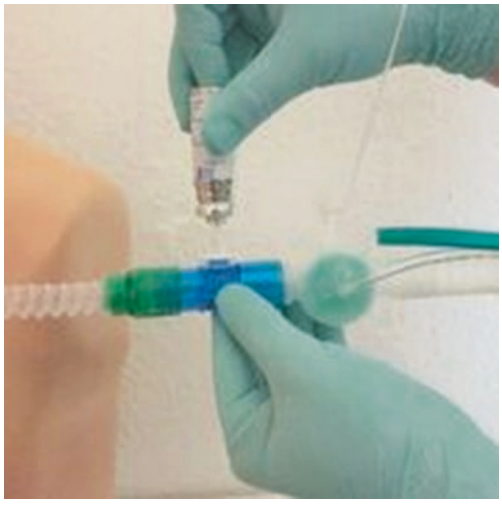


**Fig. 29.13** Use of the adapter for metered dose inhaler (Courtesy of Medisize)

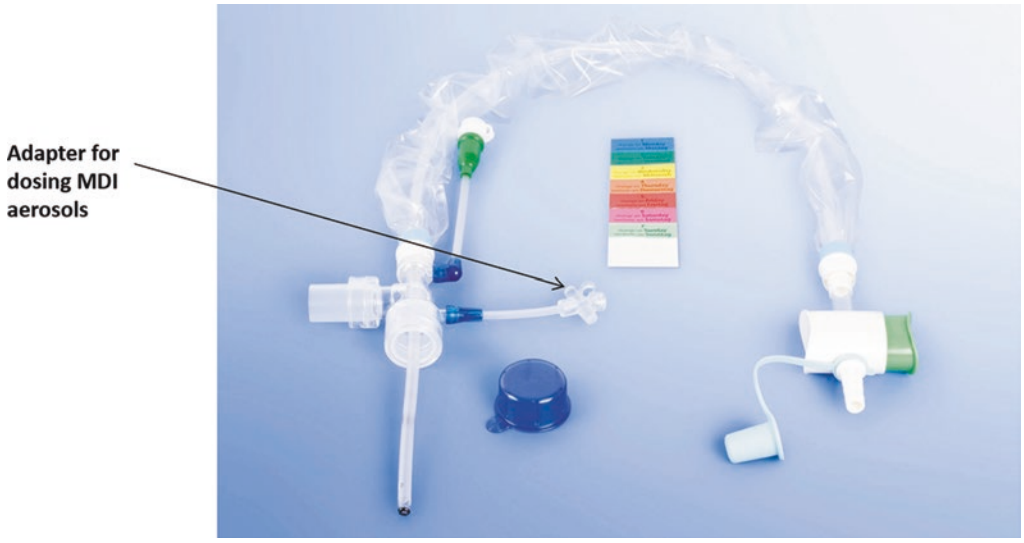



**Fig. 29.14** Application location with closed suction (Courtesy of P.J. Dahlhausen & Co. GmbH)



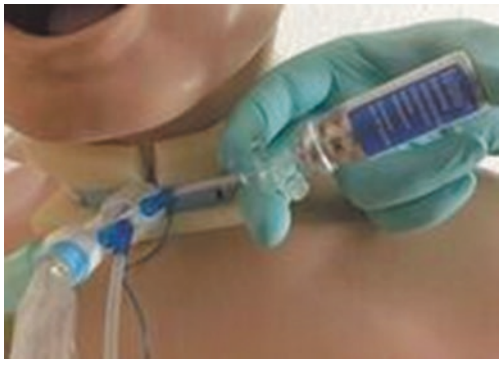


**Fig. 29.15** DA application with closed suction (Courtesy of P.J. Dahlhausen & Co. GmbH)

The application of the high inspiratory ventilation pressure produces the administration and the PEEP of the subsequent expiratory phase should produce an even distribution of the inhalation. However, the problem remains that part of the administered amount of metered dose aerosol is deposited in the system on the walls.

The spray must be applied at the time of inspiration. It would be advantageous if the inspiratory air could be held for a few seconds, for example by an "inspiration hold" installed on various ventilators.

### 29.4.4 Nebuliser Systems

There are three systems available for nebulization of drugs, which are used in outpatient ventilation (◘ Table 29.3 and ◘ Fig. 29.16).

The aerosols generated in this way reach the lungs with the mechanical inspiratory current. This type of inhalation is usually carried out for 5–15 min. Since the aerosols are liquids, the nebulisers must be aligned vertically (◘ Figs. 29.17, 29.18, 29.19, 29.20 and 29.21). If they are placed at an angle or upside down, the liquid will be lost (◘ Figs. 29.22a and 29.23a).

Most users recommend the use of nebulizers without HME filter (◘ Figs. 29.17

**Table 29.3** Nebuliser systems

| | |
|---|---|
| Nozzle nebulizer | Aerosol generation by compressed air via compressors according to the Venturi principle (Fig. 29.16 above) |
| Ultrasonic nebulizer | Aerosol generation by low-frequency ultrasound, membrane vibration (Fig. 29.16 middle) Generate the aerosol by electrically driving and vibrating a piezo crystal |
| Membrane nebulizer | Also calledmesh nebulizer (Fig. 29.16 below) They use an ultrasonic head to generate vibrations in the inhalation solution and push the droplets through the static mesh disc |

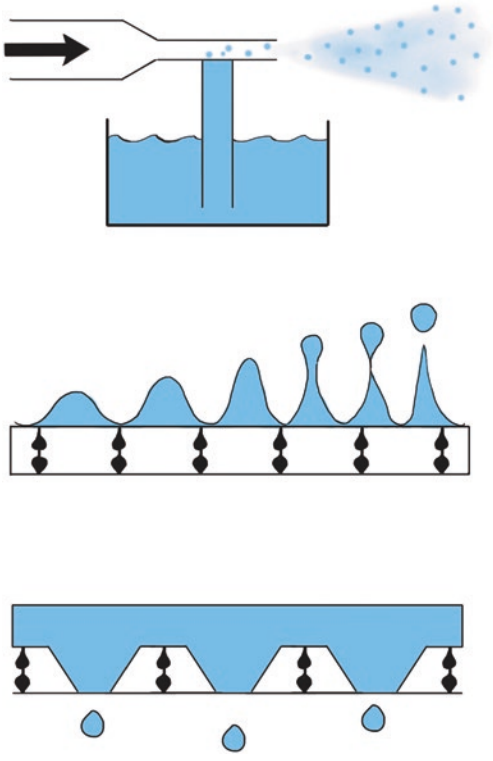


**Fig. 29.16** Nebulizer systems (Own representation, edited by Isabel Schlütter)

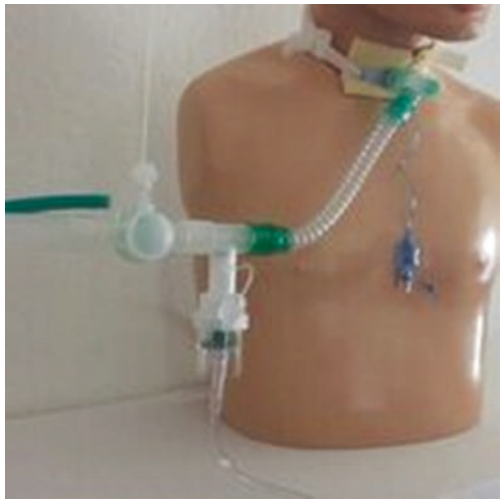


**Fig. 29.17** Nozzle nebuliser used correctly

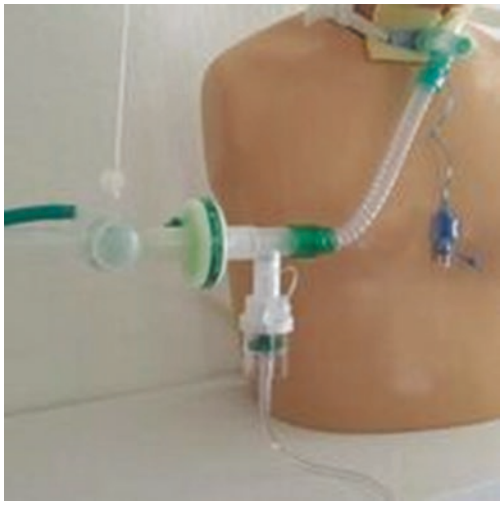


**Fig. 29.18** Nozzle nebuliser correct mounting with HME filter

and 29.20): it would not be wrong to use inhalation with HME filter. However, there is a risk that the pores of the HME filter would be blocked by the inhalation. This would then again impair ventilation (Figs. 29.18 and 29.21).

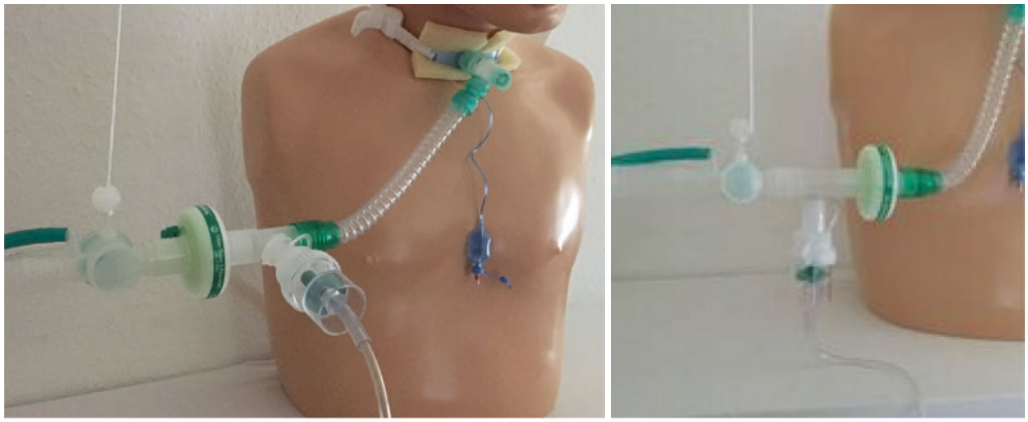


**Fig. 29.19** Vibrating diaphragm nebuliser (Aeroneb Pro®) (With friendly permission: INSPIRATION Medical GmbH)



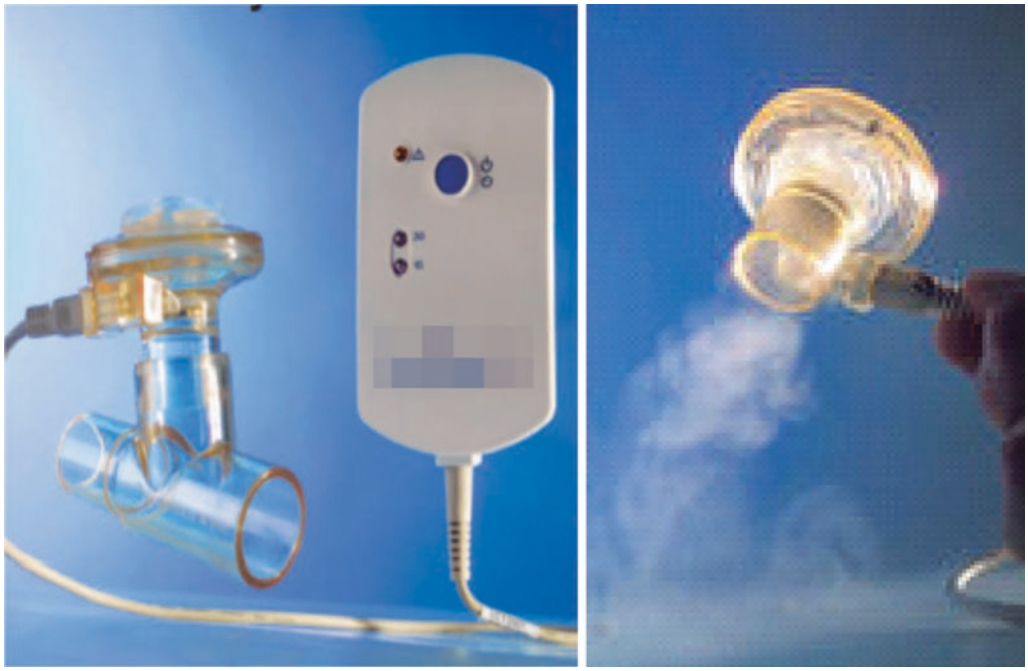


**Fig. 29.20** Aeroneb solo nebulizer correctly applied

However, the risk of incorrect application also lies in the wrong order of composition. First the nebuliser system and then the HME filter. This way the aerosol is captured by the HME and does not reach the lungs (Figs. 29.22b and 29.23b). If the HME filter is removed for inhalation, it must be stored cleanly in case it is to be used again afterwards.

When using the nebulizers with an active humidification system, this remains active and in operation. When using the

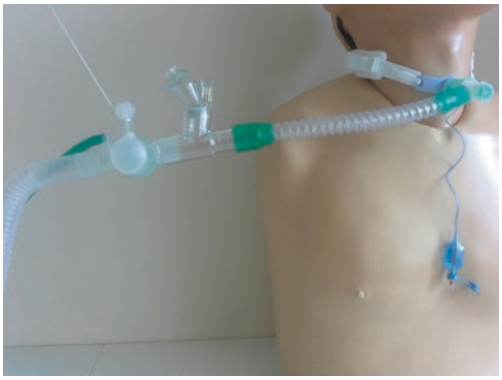


**Fig. 29.21** Aeroneb solo nebulizer correct installation with HME filter

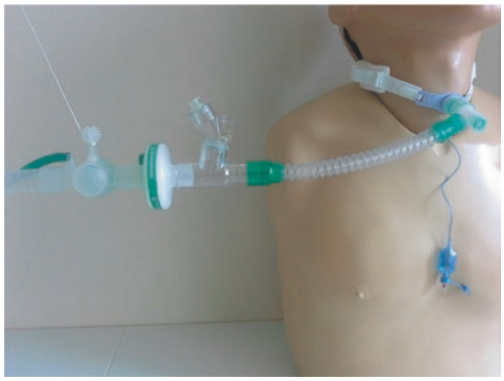
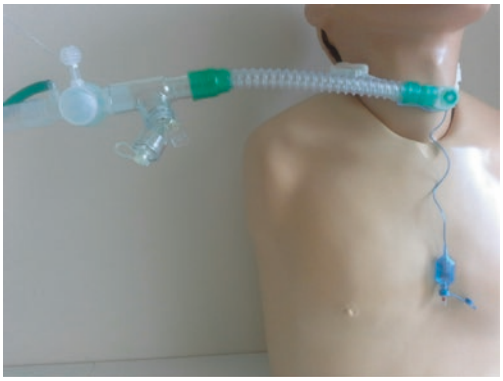


**Fig. 29.22** Nozzle nebuliser incorrect application

a



b

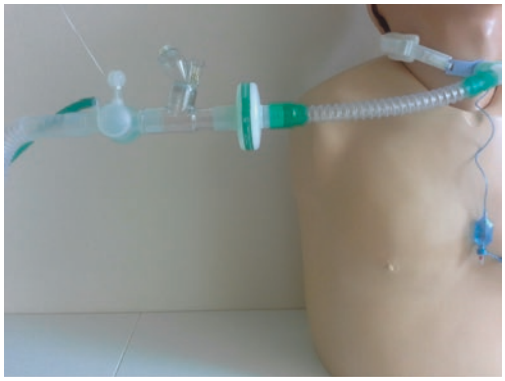


**Fig. 29.23** Aeroneb solo nebuliser incorrect use

nebulizers with an active humidification system, no HME filter is used either. Inhalation can therefore be performed without any problems. It can be recommended to disconnect the nebulizer system after use. Nebulization should be performed 4–8 times a day, depending on the doctor's instructions.

When the nebulisation interval is over, the HME filter must be replaced for breathing air conditioning. Usually, the nebulizer is removed and the HME filter is put back in in one step. However, this means the repeated dis- and reconnection of the ventilator and thus may involve hygienic risks.

The nebuliser should be stored clean and dry. It can then be used during the subsequent intervals. If the nebuliser remains in the breathing tube system, this increases the dead space, especially if the nebulisation is carried out with HME filter. The ventilation of the lungs may then be too low. Hypoventilation would be the consequence.

If the nebuliser remains, residual fluids can accidentally enter the lungs via the goose gargle and tracheal cannula. This corresponds to an aspiration. This in turn increases susceptibility to infection. The comfort for people is generally impaired, because even more equipment is "attached" to the person.

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