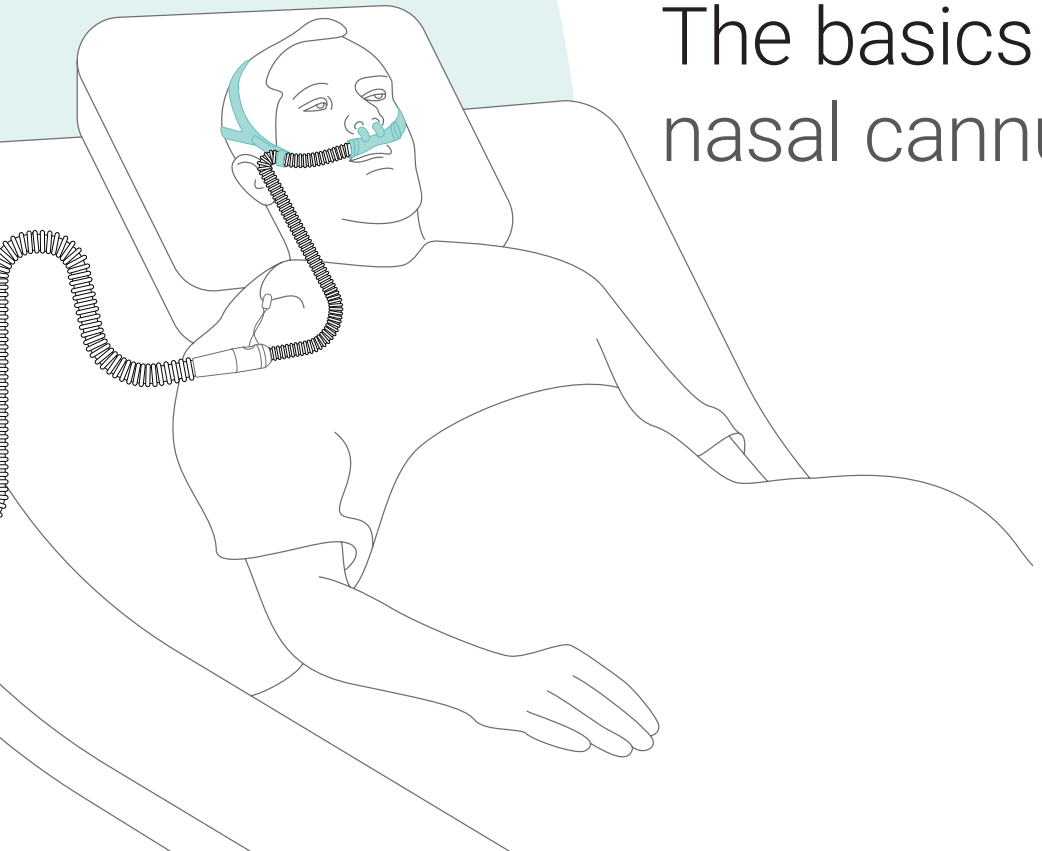

The basics of high flow nasal cannula therapy

HAMILTON MEDICAL

Synonyms and abbreviations

There is a range of terminology used for high flow nasal cannula (HFNC) therapy: HFNC supportive therapy, high flow therapy (HFT), nasal high flow (NHF), high flow (HF), high flow nasal cannula oxygen therapy, heated humidified high flow therapy (HHHF), high flow oxygen (HFO) therapy, and high flow oxygen therapy (HFOT). Hamilton Medical uses the term high flow nasal cannula (HFNC) therapy.

ARF – acute respiratory failure
CO2 – carbon dioxide
COT – conventional oxygen therapy
EELV – end-expiratory lung volume
ETI – endotracheal intubation
FiO2 – fraction of inspired oxygen
NIV – noninvasive ventilation
O2 – oxygen
PaO2 – partial pressure of oxygen
PEEP – positive end-expiratory pressure
PIF – peak inspiratory flow
RR – respiratory rate
SpO2 – oxygen saturation
VE – minute volume
WOB – work of breathing

Note: The term HFNC refers to the therapy itself irrespective of the interface used (nasal cannula or tracheostomy connector).

Content overview

Your ventilation expert

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Introduction

High flow nasal cannula therapy is a type of respiratory support that delivers heated and humidified gas with a controlled concentration of oxygen to your patients. This therapy has become increasingly popular for hypoxemic respiratory failure.

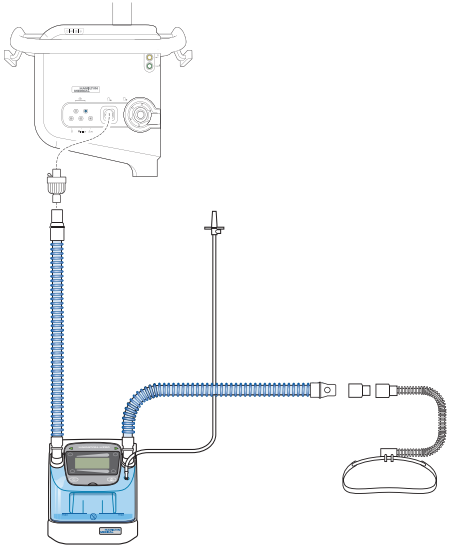
HFNC is used during early noninvasive management of acute respiratory failure, and has proven to be safe and effective as a noninvasive ventilation method[1].

HFNC has been shown to be potentially useful and efficient in other applications such as major post-operative care, immunocompromised patients, for preoxygenation, or during bronchoscopy[2].

This e-book focuses on the basics of high flow nasal cannula therapy for your daily clinical practice.

Introduction

The system used to deliver HFNC requires the following components: a gas blender and flow meter, an active humidifier, a heated inspiratory circuit, and a nasal cannula or a tracheostomy connector as an interface. When we talk about high flow nasal cannula, we need to keep in mind the four elements that describe this therapy: flow, oxygen, heat, and humidity.



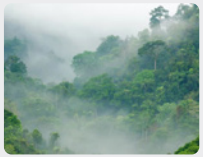
The four elements of HFNC

Flow

Oxygen

Heat

Humidity



Introduction

If we take a closer look at the meaning of each element, the advantages of using HFNC are clear:

Flow

The higher flow rates allow you to set the inspiratory flow to adequately meet or even exceed the inspiratory demand of the patient.

Oxygen

You can set the FiO2 more accurately within a range of 21% to 100%. However, consider escalating treatment if FiO2 of greater than 60% is needed to achieve the targeted SpO2.

Heat

The gas should be heated to the core body temperature of 37°C (except during NIV where the default temperature is 31°C).

Humidity

The breathing gas is saturated close to 100% relative humidity to meet the physiologic demands.

Did you know that the inspiratory demands of adult patients with acute respiratory failure can range from 30 l/min to more than 120 l/min[1]?

What are the benefits?

What are the benefits

We can divide the benefits of HFNC into clinical and physiologic as follows:

Clinical benefits[1]

- Improved patient comfort and compliance with the treatment
- Better patient tolerance due to the warmth and humidity of inspired air
- Ease of use

Physiologic benefits[1]

- Improved oxygenation because higher inspiratory flows mean reduced oxygen dilution
- Reduction of dead space and CO2 rebreathing compared with low flow oxygen therapy and NIV
- Reduced work of breathing associated with an improvement in respiratory rate, as well as a reduction in heart rate with a significant improvement in SpO2 measurements

How does it work?

From low flow to high flow

Before we dive into the working principles of high flow nasal cannula, we need to address the limitations that are typical of low flow oxygen delivery systems. This will help you better understand the beneficial effects of HFNC for your patients.

Low flow oxygen therapy

With conventional oxygen delivery devices, the peak inspiratory flow rate in acute respiratory failure patients exceeds the delivered flow of oxygen. Typical low flow systems provide supplemental O2 directly to the airway at a flow of 8 l/min or less. This O2 provided by a low flow device is always diluted with ambient air (with 21% FiO2); the result is a low and variable FiO2.

This variable FiO2 may be associated with one or more of the following: the interface used to deliver oxygen, the respiratory rate, the peak inspiratory flow and how the patient breathes (through the mouth or nose).

Low flow nasal cannulas
Only 22% to 40% of oxygen at flow rates of up to 6 l/min in adults

Low flow oxygen masks
Only 35% to 50% of oxygen at flow rates from 5 to 10 l/min

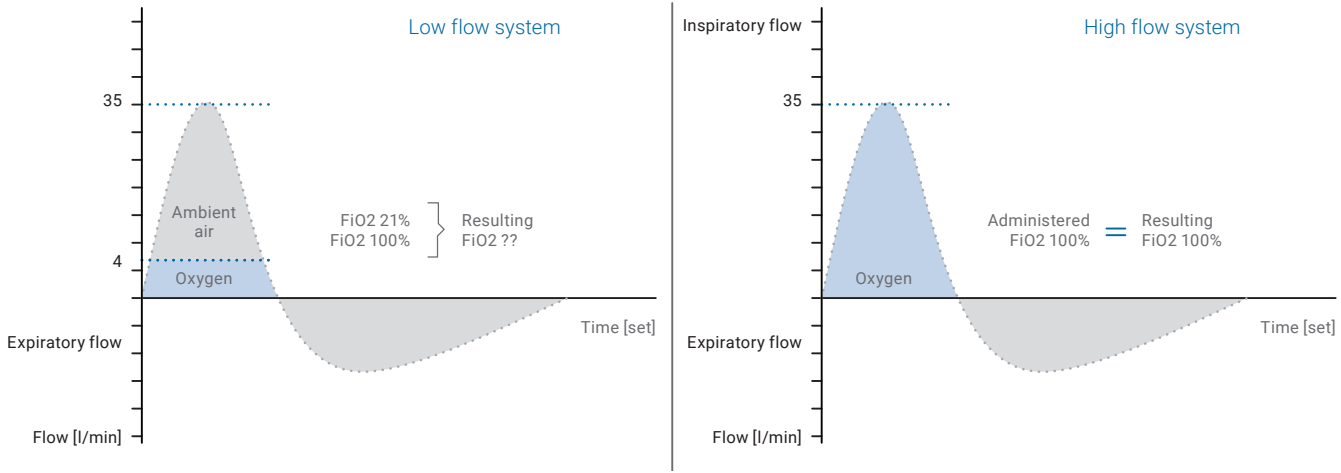
The use of humidification is recommended when oxygen is supplied through a nasal cannula at flow rates of more than 4 l/min[1].

High flow nasal cannula

- In contrast to low flow oxygen therapy, the gas flow rate and FiO2 in HFNC can be adjusted independently of one another, depending on the patient‘s inspiratory demands.
- With high flow nasal cannula systems, the FiO2 is delivered more accurately and can be set from 21% to 100%.
- As mentioned already, the higher flow rates are able to meet or even exceed the patient‘s peak inspiratory flow rate.
- The blend of air and oxygen delivered to the patient is fully heated and humidified by the humidification chamber and the single limb heated breathing circuit. This breathing circuit contains heater wires within the tubing wall that minimize condensation.
- The therapy is delivered directly into the patient‘s nostrils through a nasal cannula.

Low flow vs. high flow nasal cannula therapy

During normal inspiration, the PIF demand is 30 to 40 l/min. With high flow nasal cannula therapy, the administered FiO2 would equal the inhaled FiO2, while in the case of a low flow system, the inhaled FiO2 would be less than the administered FiO2 because it is diluted with ambient air[3].

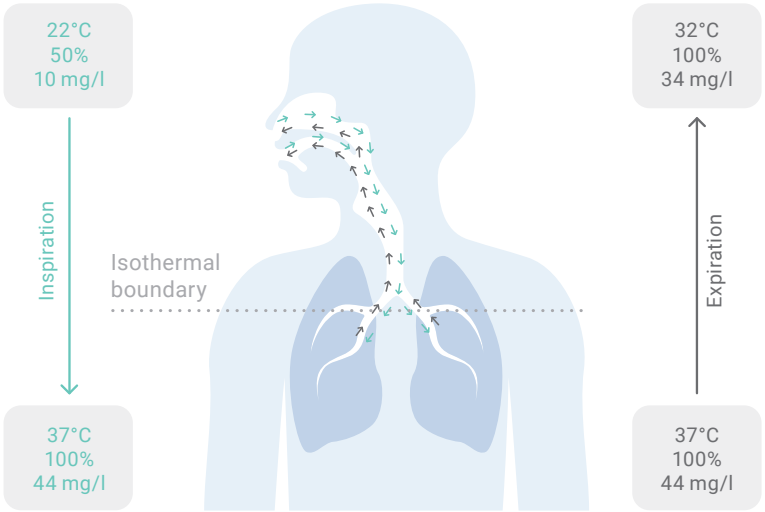


Low flow vs. high flow nasal cannula therapy

For higher flows, adequate humidification is fundamental because it improves the tolerance and compliance of the treatment. HFNC systems require an active heated humidifier to achieve optimal body temperature (37°C in adults and 34°C to 37°C in pediatric patients) with a humidity output of higher than 33 mg H2O/l and close to 100% of relative humidity.

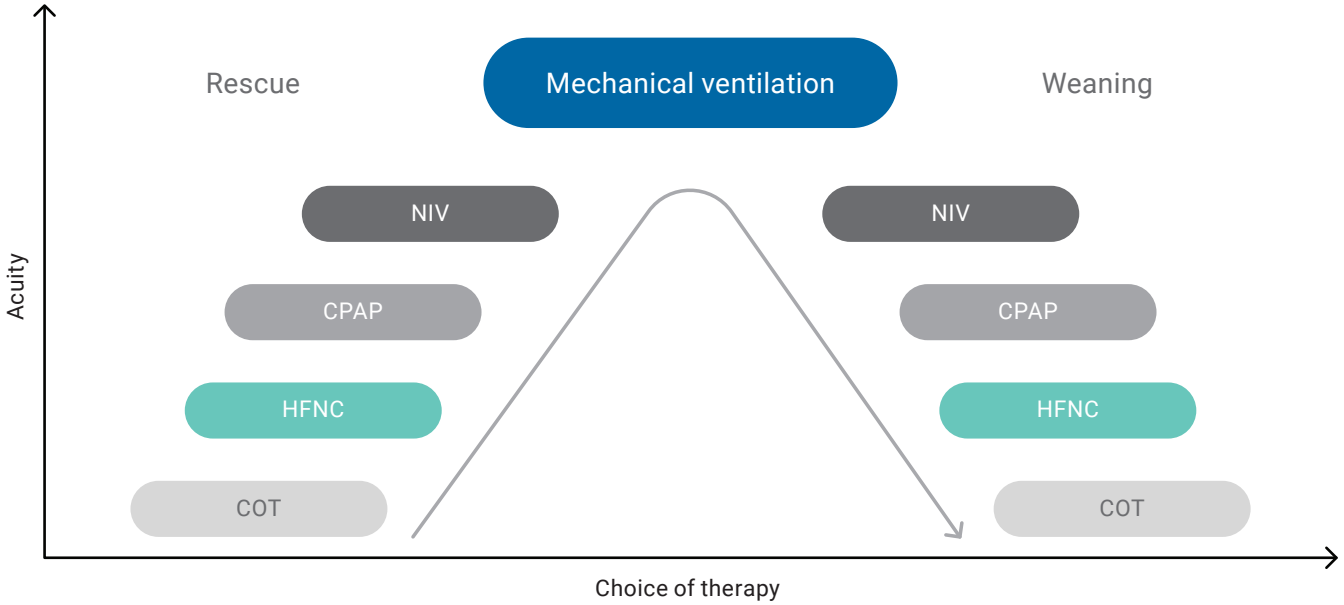
These conditions provided by HFNC promote:

- Improved lung compliance[1]
- Improved gas distribution in the lungs[1]
- Improved mucociliary clearance[1]
- Decreased airway resistance[1]
- Increased patient comfort[1]



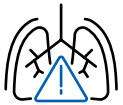
When to consider high flow nasal therapy

HFNC is considered the first-line therapy for patients with acute hypoxemic respiratory failure and can be part of a treatment strategy, whether during escalation or weaning.



Recommendations for HFNC[4,5]

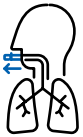
Hypoxemic respiratory failure



Strong recommendation

- ✓ Lower intubation rates
- ✓ Reduction in escalation of respiratory support
- ✓ Cost savings in terms of equipment and intubations avoided

Post-extubation



Conditional recommendation

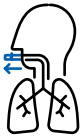
- ✓ Lower intubation rates (compared with COT)
- ✓ Reduction in post-extubation respiratory failure

Post-operative HFNC in high risk and/or obese patients following cardiac or thoracic surgery

Conditional recommendation

- ✓ Lower reintubation rate (compared with COT)
- ✓ Reduction in escalation of respiratory support (compared with COT)

Peri-intubation period



No recommendation

- ✓ Patients who are already receiving high flow should continue with HFNC during intubation

What is the clinical relevance?

Physiologic effects of high flow

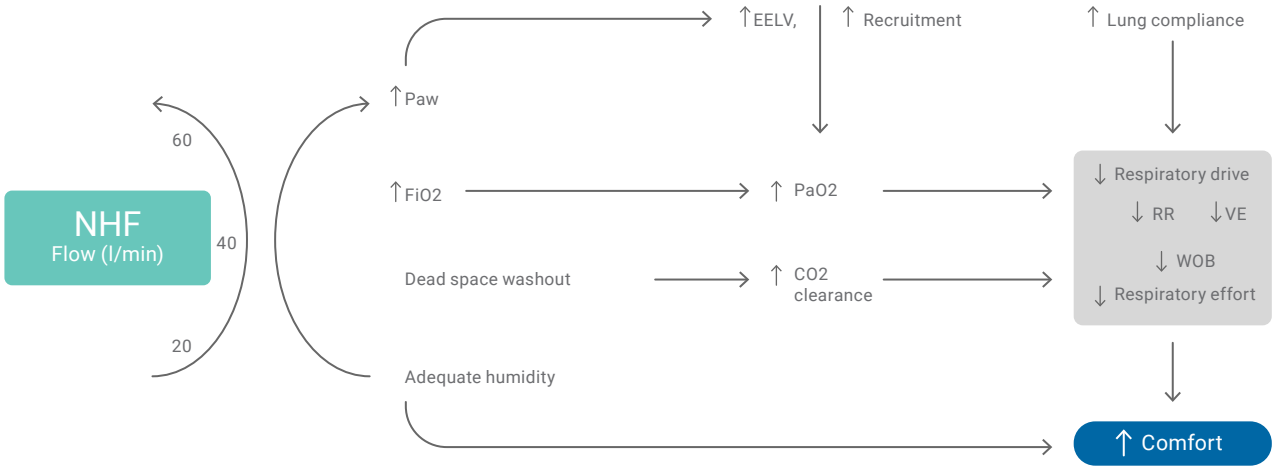
Negative end-expiratory transpulmonary pressure can cause ventilator-induced lung injury due to atelectrauma. Studies[6] have shown that HFNC has multiple physiologic effects ranging from improved lung volumes to decreased work of breathing. The main ones are as follows:

- High flow generates a washout effect in the upper airways, promoting anatomic dead-space clearance and CO2 removal
- Increases the end-expiratory lung volume and PaO2/FiO2 ratio
- Optimal strategy for administering oxygen to hypoxic critically ill patients with high respiratory demand
- Provision of low-level PEEP
- The therapy is delivered directly into the patient's nostrils through the nasal cannula

The physiologic effects of HFNC can be summarized as improved oxygenation, reduced work of breathing, improved lung protection and better comfort for the patient.

Physiologic effects of high flow

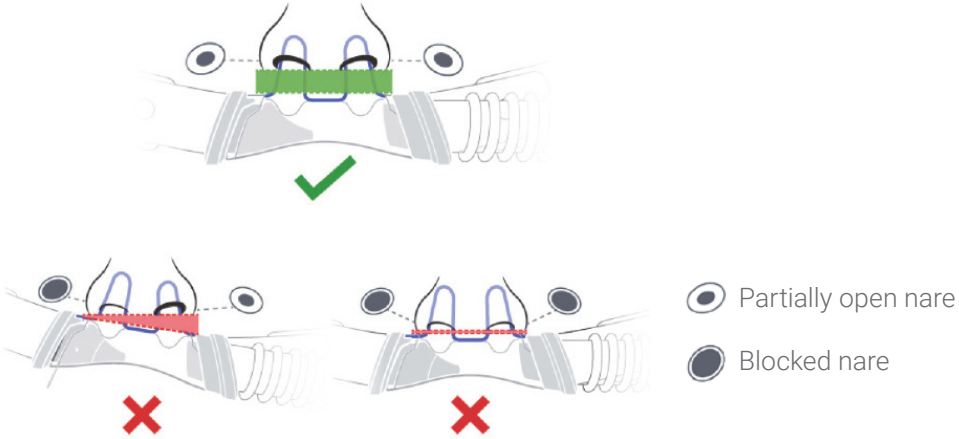
Amongst the main physiologic effects of HFNC are an increase in airway pressure and end-expiratory lung volume (EELV), and an improvement in oxygenation. These are more evident with higher flows of around 60 to 70 l/min. However, the beneficial effects on parameters such as dead-space washout, work of breathing, and respiratory rate may be achieved with intermediate flows (20 to 45 l/min)[6].



How to choose the right interface?

Choosing the right cannula size

The nasal cannula interface is an essential component for delivery of high flow nasal cannula therapy. In order to maintain an effective flush of CO2, it is important that the cannula does not occlude more than ~50% of the nares.



Note: Airway pressure increases progressively with both increasing flow rate and nasal prong-to-nares ratio.

How to adjust the settings?

Setting the flow in adult patients[7]

- Set the flow initially to between 20 and 35 l/min
- The flow can be increased progressively in steps of 5 to 10 l/min if the respiratory rate fails to improve
- Increasing flows from 15 to 45 l/min triples the reduction in anatomic dead space
- To prevent intubation, choose the highest flow tolerated by the patient

These are only general recommendations, and every patient should be treated based on their specific medical condition.

Setting the flow in pediatric patients[8]

Flow rates that exceed inspiratory demand can be set in patients under 24 months who tolerate flows of 1 to 2 l/kg/min (up to 20 l/min).

Age	Body weight (kg)	Flow range (l/min)
≤ 1 month	< 4	5–8
1–12 months	4–10	8–20
1–6 years	10–20	12–25
6–12 years	20–40	20–30
12–18 years	> 40	25–50

These are only general recommendations, and every patient should be treated based on their specific medical condition.

Setting the oxygen in all patient groups

The FiO2 is the concentration of oxygen in the gas mixture delivered to the patient. In HFNC, the FiO2 should be set as follows:

- ✓ You can set the FiO2 from 21% up to 100%.
- ✓ Titrate the FiO2 to achieve the desired SpO2 (target ranges of 92%–96% for most patients and 88%–92% for patients with chronic respiratory disease)[7].

These are only general recommendations, and every patient should be treated based on their specific medical condition.

How to monitor treatment?

Monitoring the effectiveness of HFNC

The ROX index is defined as the ratio of oxygen saturation as measured by SpO2/FiO2 to the respiratory rate. In patients with hypoxemic respiratory failure, the ROX index can be used after HFNC therapy has been initiated to help identify those who are at high risk of intubation[9].

ROX index ≥ 4.88 after two hours of treatment, indicates a high probability that intubation will not be necessary.

ROX index < 3.85 indicates a higher risk of treatment failure.

ROX index

ROX = (SpO2/FiO2)/respiratory rate

ROX ≥ 4.88 success		ROX < 3.85 consider intubation	
SpO2:	94%	SpO2:	92%
FiO2:	0.6	FiO2:	0.8
SpO2/FiO2:	157	SpO2/FiO2:	115
Rate :	25	Rate :	35
ROX:	6.27	ROX:	3.29

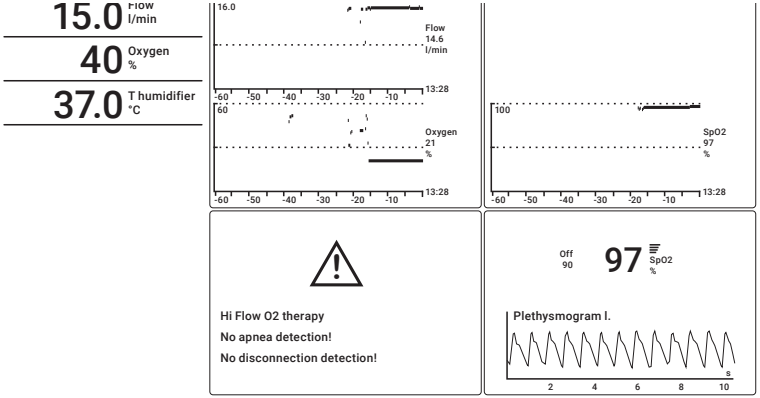
Recommendations for measuring the ROX index[9]

SpO2 monitoring

SpO2 is one of the most important parameters to monitor during HFNC. It indicates whether FiO2 needs to be re-adjusted and is useful during FiO2 titration.

How to use SpO2* measurement on your Hamilton Medical ventilator:

- Connect the sensor to the device and the patient
- Select the System tab
- Activate the SpO2 sensor



*If the SpO2 option is not installed, use external patient monitoring

SpO2 monitoring

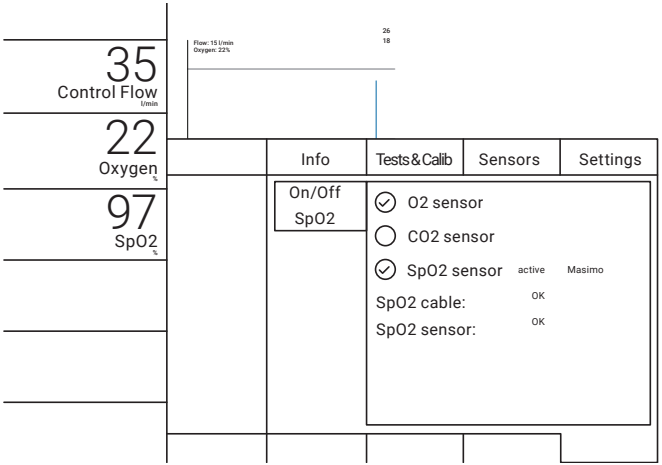
The monitoring shows the values of flow and oxygen over time so you can evaluate the therapy's progress.

How to monitor the progress of the therapy with your Hamilton Medical ventilator:

- Main monitoring parameters
- Control flow
- Oxygen

Trending graphs:

- Select either Control Flow or Oxygen



Test yourself

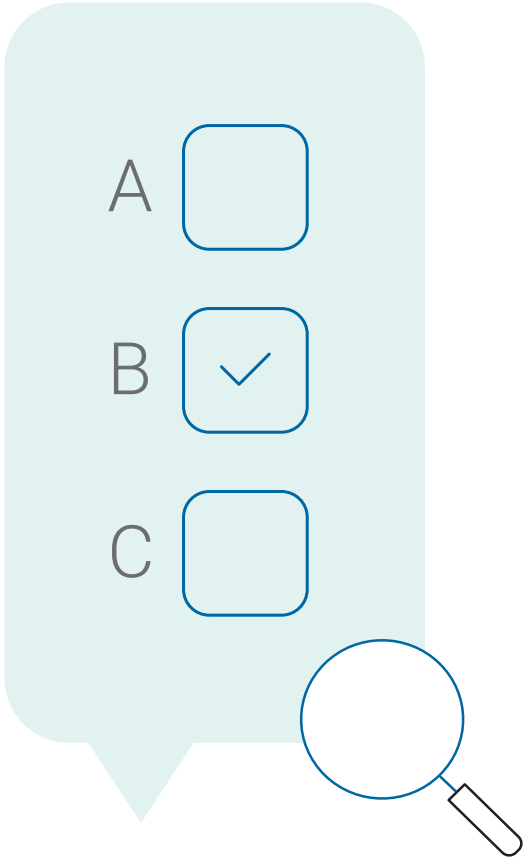
Test yourself

Now it is time to put your knowledge to the test. On the following pages you can find several questions about high flow nasal cannula therapy and the concepts mentioned in this e-book.

For each question there are three possible answers, only one of which is correct.

You can check your answers on page 37 and page 43 (for the clinical case).

Good luck!



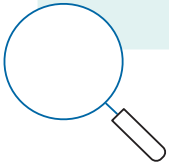
Question 1

When should we consider using high flow nasal cannula therapy?

a) Preoperative patients

b) Patients with acute hypoxemic respiratory failure

c) Patients with chronic hypercapnia



Question 2

Which of the following is a benefit of high flow nasal cannula therapy?

a) Increased work of breathing

b) Increased end-expiratory lung volume and PaO2/FiO2 ratio

c) Washout effect in the upper airways promoting anatomic dead-space clearance and CO2 removal

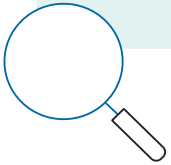
Question 3

What should you set the flow rate to when starting high flow nasal cannula therapy?

a) 20 to 35 l/min

b) 15 to 20 l/min

c) 60 l/min



Question 4

How is the ROX index calculated?

a) (RR/SpO2)/FiO2

b) (FiO2/SpO2)/RR

c) (FiO2/SpO2)/HF

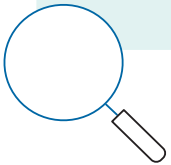
Question 5

Which ROX index values indicate an increased risk of treatment failure?

a) ROX index < 4.88

b) ROX index < 5.35

c) ROX index < 3.85



Solutions

Question 1	b) Patients with acute hypoxemic respiratory failure
Question 2	c) Washout effect in the upper airways promoting anatomic dead-space clearance and CO2 removal
Question 3	a) 20 to 35 l/min
Question 4	b) (FiO2/SpO2)/RR
Question 5	c) ROX index < 3.85

Clinical case

Scenario: Emergency transfer of a patient from the normal ward to the ICU due to acute respiratory failure. Following a partial liver resection three days ago, the patient now has rising inflammatory marker levels and a suspected septic event. The patient arrives on the ward with tachypnea and an SpO2 of 84%. He is hemodynamically stable with a heart rate of 118 bpm and blood pressure of 90/60 mmHg. He is administered 10 l/min of oxygen through an oxygen mask.

Current blood gases:
PaO2: 72 mmHg (9.6 kPa)
PaCO2: 52 mmHg (6.93 kPa)
pH: 7.34

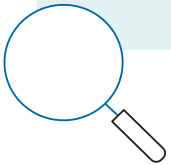
Clinical case – Question 1

What would be your first-line therapy to improve the patient's respiratory situation?

a) NIV

b) Intubation

c) HFNC



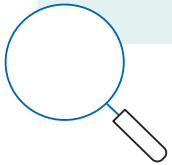
Clinical case – Question 2

For HFNC therapy in this patient, how high would you set the flow?

a) Between 25 and 40 l/min

b) Titrate the flow to as high as the patient can tolerate

c) Flow rate above 60 l/min would be appropriate



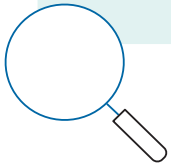
Clinical case – Question 3

At what oxygen level would you start the therapy?

a) 21%

b) 50% to 80%; after reaching the desired SpO2, oxygen is lowered to maintain the SpO2

c) Always start with 100%



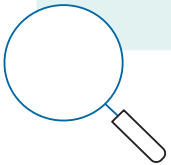
Clinical case – Question 4

After 30 min of HFNC therapy, RR decreases and SpO2 is stable at 90%. You decide to continue with the therapy. After 2 hours, you measure the ROX index. The result is 5.93 (SpO2 - 89% , FiO2 - 0.6, RR - 25 bpm). How would you proceed now?

a) Continue therapy without changes

b) Consider ETI

c) Change to NIV



Solutions - Clinical case

Question 1	c) HFNC
Question 2	b) Titrate the flow to as high as the patient can tolerate
Question 3	b) 50% to 80%; after reaching the desired SpO2, oxygen is lowered to maintain the SpO2
Question 4	a) Continue therapy without changes

Appendix

HFNC and Hamilton Medical

Hamilton Medical ventilator:

- With HiFlowO2 mode as an easy-to-add software option
- Remote access to HAMILTON-H900 controls and status (except HAMILTON-C3)

HAMILTON-H900 humidifier:

- Active humidification with dedicated high flow mode
- Preassembled breathing circuit sets with integrated temperature probe

High flow interfaces:

- In2Flow interfaces for adult and pediatric* patients
- Nuflow nasal cannulas for neonatal patients

*Pediatric patients > 2 years old.

HFNC and Hamilton Medical

Device	Flow range (l/min)	Flow range (l/min)
HAMILTON-C1/T1/MR1	2–30 (US market: limited to 60 l/min)	2–100 (US market: limited to 15 l/min)
HAMILTON-C3	1–12	2–80
HAMILTON-C6	2–30	2–100
HAMILTON-G5/S1	1–12	1–60

Neonatal patients

Adult and pediatric* patients

*Pediatric patients > 2 years old.

HAMILTON-H900 humidifier

The HAMILTON-H900 humidifier was developed with the focus on ease of use and patient safety. This means you can concentrate on other important aspects of patient care.

- Integrated temperature probe
- Wall-heated, all-in-one breathing circuit sets
- Adjustable temperature and humidity settings
- Remote access to humidifier controls and status*
- Predefined settings for high flow nasal cannula therapy

*Not available in all markets.

In2Flow interfaces

The In2Flow portfolio includes nasal cannulas for adult and pediatric* patients in three different sizes, and a tracheostomy connector.

- Small (orange) ≤ 60 l/min
- Medium (blue) ≤ 80 l/min
- Large (green) ≤ 100 l/min
- Tracheostomy connector ≤ 60 l/min

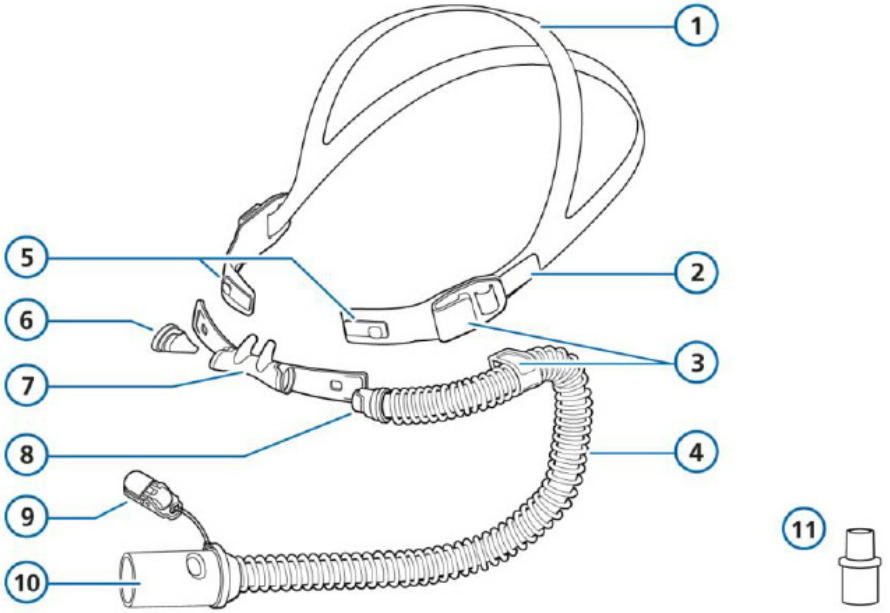
Resourceful packaging:

- Printed scale for the prongs to measure the nostrils and choose the right size
- Empty text field for the patient's number or name
- Color-coding to identify the right size before you open the packaging
- Free from DEHP, PVC, and Latex

*Not available in all markets.

In2Flow Nasal cannula

1) Head strap
2) Adjustment strap
3) Delivery tube holding clip
4) Delivery tube
5) Quick release
6) Sealing plug
7) Face mount, nasal prongs
8) Delivery plug, locking ring
9) Securing clip
10) Connection to inspiratory limb, OD22
11) Adapter, OD15, for use with dual limb breathing circuit



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