

# Infant Flow<sup>®</sup> LP nCPAP system

## Clinical training workbook



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***Initiating and maintaining effective nCPAP therapy is a critical step in helping respiratory- compromised infants achieve successful recovery and develop normal respiratory function. When used according to your facility's treatment protocols and with this training workbook, the Infant Flow LP nCPAP system can effectively deliver nCPAP therapy to help improve patient outcomes.***

# Infant nasal CPAP



## Introduction

Worldwide each year, approximately 15 million (*1 out of every 10*) babies are born prematurely.<sup>1</sup> Premature or low-birth weight (LBW) infants are at a high risk for respiratory problems due to underdeveloped lungs. Common neonatal respiratory conditions include apnea of prematurity, respiratory distress syndrome, transient tachypnea of the newborn (TTN), meconium aspiration syndrome, pulmonary edema and post-extubation support. These conditions are often associated with decreased pulmonary compliance and functional residual capacity (FRC).<sup>1,2</sup> Several of these infants will require respiratory support.

Respiratory distress syndrome (RDS) is a condition that strains normal respiration due to the lack of natural surfactant production. Approximately 50% of neonates born at 26 to 28 weeks gestation and 30% of neonates born at 30 to 31 weeks gestation develop RDS.<sup>2</sup>

## CPAP overview

### What is surfactant?

Surfactant is a phospholipid, which reduces surface tension to increase lung compliance.

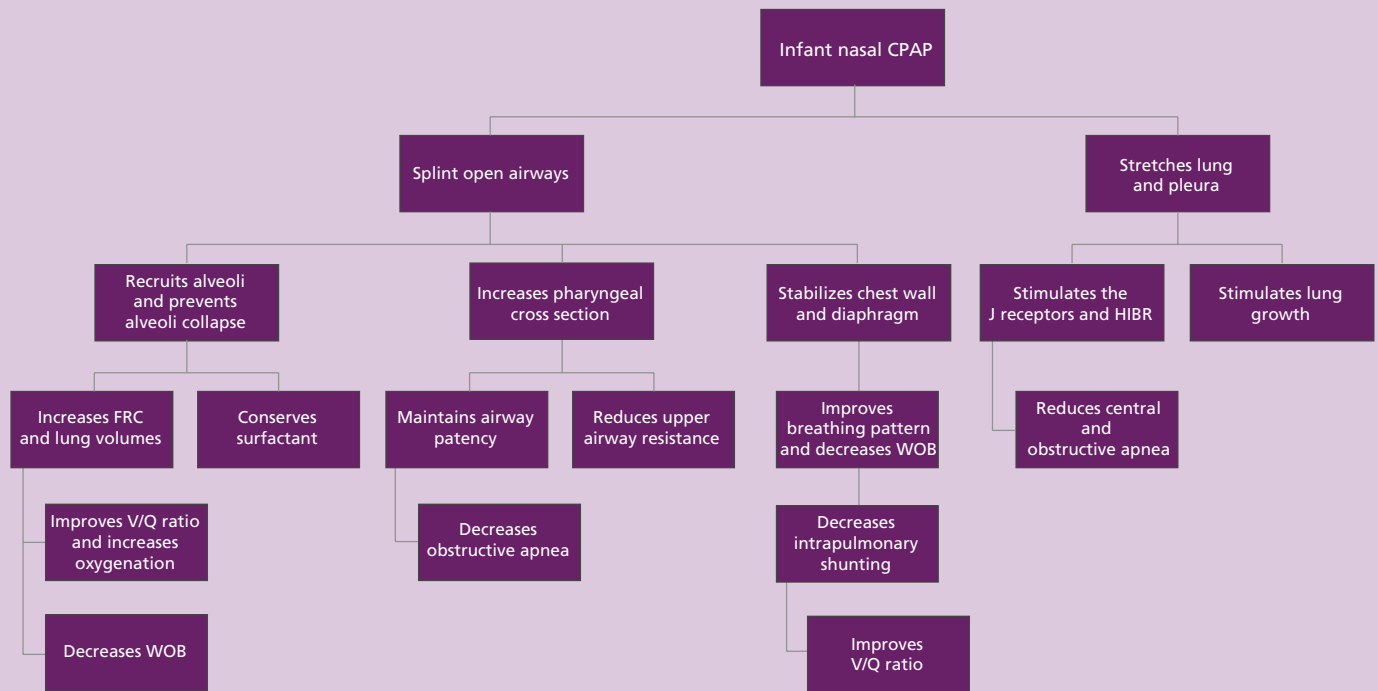
Artificial surfactant may be given to help reduce surface tension, increase compliance and improve ventilation. Without additional respiratory assistance, many infants have difficulty establishing the adequate functional residual capacity (FRC) required to maintain normal respiration.

### Respiratory support

Several options are available to help the clinician provide respiratory support to the neonatal patient. Historically, the initial treatment for infants with respiratory problems was mechanical ventilation via an artificial airway. Intubation presents a variety of challenges for any patient but

compounds problems with premature infants. Given the potential complications of intubation, many physicians opt for a less invasive approach for spontaneously breathing infants that utilizes continuous positive airway pressure (CPAP). As infants are preferential nose-breathers, nasal CPAP (nCPAP) is the preferred method for treatment delivery. CPAP enhances alveolar recruitment decreasing pulmonary vascular resistance and intrapulmonary shunting, stabilizes FRC and improves oxygenation. By increasing surface area to alveolar gas exchange, CPAP decreases V/Q mismatch. The goal of CPAP therapy is to maintain normal lung volumes and oxygenation, while enabling the infant to breathe on their own.<sup>3,4</sup> Physiologic effects of CPAP are represented in the organizational chart on page 2.

## Physiologic effects of nasal CPAP in neonates<sup>3-4,10</sup>



Nasal (nCPAP) is associated with improved respiratory mechanics and decreased chronic lung disease (CLD) rate.

### What is nasal CPAP (nCPAP)?

nCPAP is the application of positive pressure to the airways of a spontaneously breathing infant throughout the respiratory cycle. nCPAP is a continuous flow of gas administered through nasal prongs inserted in the nares or by a nasal mask placed around the perimeter of the nose. The positive pressure, usually 4 cmH<sub>2</sub>O to 8 cmH<sub>2</sub>O, acts as a splint, which can help prevent alveoli collapse.

BiPhasic CPAP alternates between two levels of CPAP at a set time interval. The infant can breathe at both CPAP settings. The BiPhasic mode helps increase the infant's tidal volume and may stimulate the respiratory drive center.

### Advantages of CPAP

- Increases FRC
- Maintains and increases lung volume
- Improves lung compliance
- Reduces work of breathing (WOB) and airway resistance
- Provides a noninvasive procedure
- Allows small airways to develop
- Promotes the use of natural surfactant
- Promotes easy application
- Provides cost effectiveness
- Helps prevent extubation failure in some infants
- Stabilizes the airway diaphragm and chest wall
- Decreases incidence of chronic lung disease (CLD)

### Indications for use<sup>2-5</sup>

- Abnormalities on physical examination
  - Increased WOB
  - Increased respiratory rate
  - Intercostal and substernal recession
  - Grunting and nasal flaring
  - Pale skin color
  - Restlessness
- Deteriorating arterial/capillary blood gas values (e.g., hypercapnea)
- Increased oxygen requirements to maintain a  $\text{SaO}_2$  greater than 92% with  $\text{FiO}_2 > 60\%$
- Atelectasis and infiltration
- Clinical conditions
  - Apnea of prematurity
  - Chest infections (e.g., pneumonia)
  - Transient tachypnea of the newborn (TTN)
  - Mild meconium aspiration
- Weaning/Post-extubation support

### Contraindications for use<sup>2-5</sup>

- Severe cardiovascular instability
- Respiratory failure defined as  $\text{pH} < 7.25$  and  $\text{PaCO}_2 > 60$  mmHg torr

- Congenital malformations of the upper airway (cleft palate, choanal atresia or tracheoesophageal fistula)
- Congenital diaphragmatic hernia or untreated bowel obstruction
- Poor respiratory drive unresponsive to CPAP therapy (frequent apnea episodes associated with oxygen desaturation and/or bradycardia)

### What is work of breathing?

WOB describes the amount of effort required to breathe. Any therapy that introduces incoming pressure to a patient's respiratory system potentially adds imposed WOB. Infants with RDS experience elevated WOB levels, and by expending additional effort to inhale and exhale against pressurized gas, the infant consumes precious calories overcoming the high WOB level. These calories could otherwise be spent on vital recovery and growth processes. In addition to helping the infant conserve energy, a WOB reduction may reduce stress and anxiety levels.

### Potential problems associated with CPAP therapy<sup>3,5,6</sup>

Clinicians should be aware of the possible hazards and complications associated with CPAP, and take the necessary precautions to ensure safe and effective applications, such as:

- Possible loss of prescribed pressure and decreased  $\text{FiO}_2$  due to mouth breathing
- Increased intrathoracic pressure reducing venous return, which may lower cardiac output
- Barotrauma leading to surgical emphysema/pneumothoraces
- Aspiration
- Deterioration in the respiratory condition, requiring immediate ventilation
- Patient discomfort from prong/mask intolerance
- Nasal septal injury (e.g., columella necrosis)
- Blanching of the nares
- Dry mouth and airways
- Gastric inflation





## CPAP modalities

### What are the treatment options?

A variety of technologies have been employed in nCPAP delivery throughout the years.

**Conventional CPAP (V-CPAP):** Utilizes a traditional mechanical ventilator to deliver a constant flow of gas. CPAP is created by changing the expiratory port orifice size. The ventilator equipment is comprehensive and expensive.

**Bubble CPAP (B-CPAP):** Utilizes a constant flow of heated and humidified gas. The level of pressure is controlled by the depth of the exhalation tube inserted into a water container. The pressure can increase if condensate collects in the tubing, the flow rate changes or the water evaporates from the container. B-CPAP lacks system alarms and imposes a higher WOB due to the constant flow and inability to entrain flow during inspiration.<sup>(16,18,19)</sup>

**High flow nasal cannula (HFNC):** Has not been cleared by the FDA for nasal CPAP delivery. HFNC utilizes a constant flow of heated, humidified gas that potentially delivers a positive distending pressure. The level of therapy cannot be measured and fluctuates depending on body position, oral leaks, nasal secretions and the size and weight of the patient. HFNC does not contain critical alarms that ensure the safe delivery of therapy.

**Variable flow CPAP (VF-CPAP):** Incorporates a generator that redirects the heated and humidified gas flow away from the patient during exhalation and allows air entrainment during periods of high inspiratory effort.

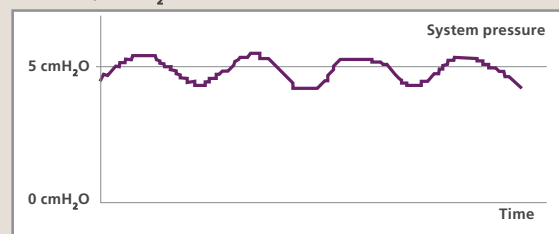
By redirecting the gas, VF-CPAP offers a lower imposed WOB and less expiratory resistance compared to other nCPAP technologies. Because the pressure is created and measured at the nares, the variable flow technology

provides the most stable pressure, even in the presence of leaks up to 6 LPM.

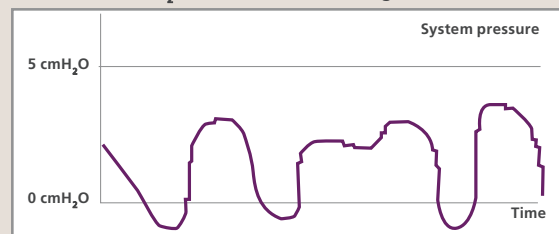
Pandt and Associates demonstrated that the Infant Flow variable flow technology delivered a consistent level of CPAP with little fluctuations. In contrast, the conventional CPAP did not reach the desired level of 5 cmH<sub>2</sub>O, and the pressure fluctuated significantly throughout the breath cycle.<sup>9</sup>

Using a variable flow generator with a dedicated CPAP driver provides a measurable therapy with system alarms to help ensure safe and effective therapy.

Infant Flow  
8 Lts flow, 5 cmH<sub>2</sub>O



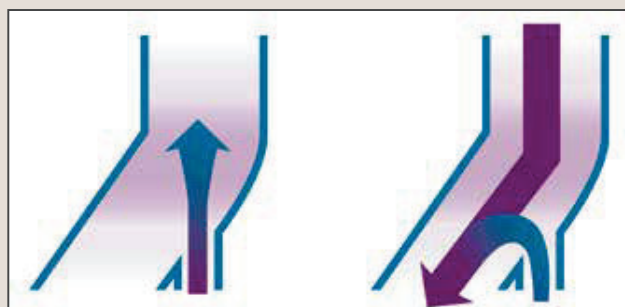
Conventional CPAP  
17 Lts flow, 5 cmH<sub>2</sub>O with 5 Lts reservoir bag



Moa, G., Nilsson, K. et al. *Crit Care Med*, 1988, 16(12):1238–1242.

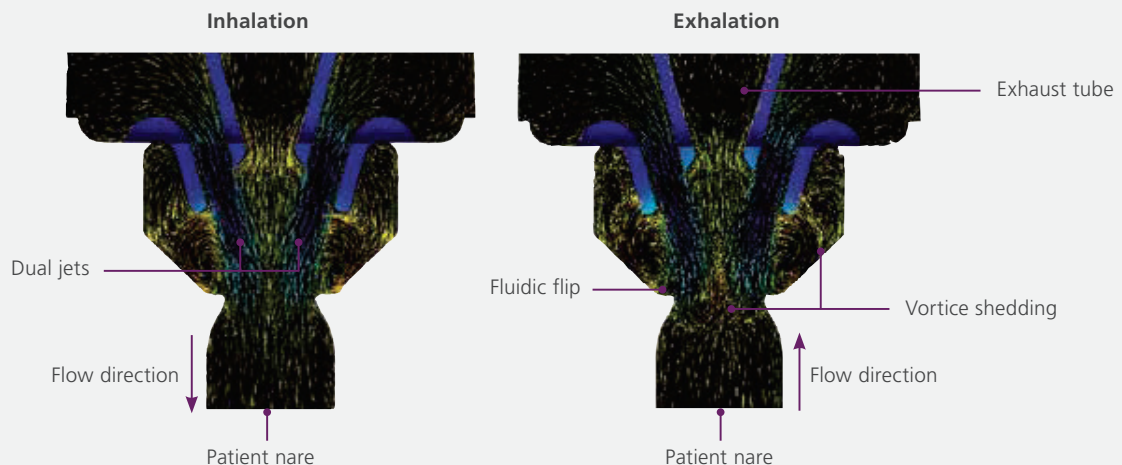
### Infant Flow variable flow

**Inspiration:** Gas flow converted to pressure reducing the WOB and maximizing the pressure stability at the patient interface.



**Expiration:** Gas flow flipped away from the nasal prongs to the expiratory tube. The residual gas pressure provided by the continuous gas flow creates a stable CPAP throughout the respiratory cycle.

## Variable flow technology



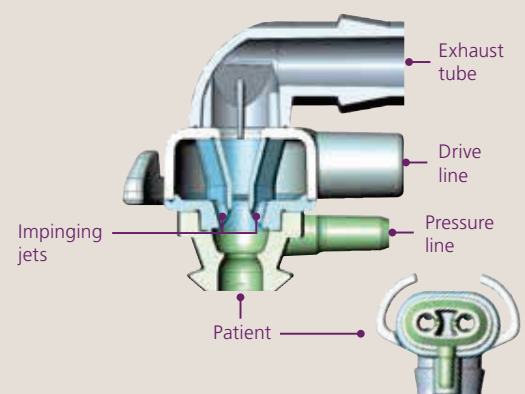
### What is variable flow technology?<sup>10,11</sup>

The Infant Flow LP patented dual-jet variable flow generator utilizes fluidic technology to deliver a constant CPAP at the airway proximal to the infant's nares. Without moving parts or valves, the generator provides consistent performance. The level of CPAP created is proportional to the flow provided by the driver; for example, 9 LPM creates approximately 5 cmH<sub>2</sub>O CPAP. The variable flow generator uses Bernoulli's Principle via injector jets directed toward each nare. If the infant pulls additional flow, the venturi action of the injector jets entrains additional flow from either the source gas or exhalation tube reservoir. During exhalation, the incoming gas flow redirects away from the infant. This action is referred to as the "fluidic flip." By redirecting the gas, variable flow nCPAP reduces the imposed WOB. The infant can exhale freely and conserve precious calories for development. In summary, the direction of gas flow in variable flow devices depends on the patient's respiratory cycle. The flow "flips" away from the nares when the infant exhales and then, "flips" back as the exhalation phase ends. The response is almost instantaneous as it occurs at the patient's nares.

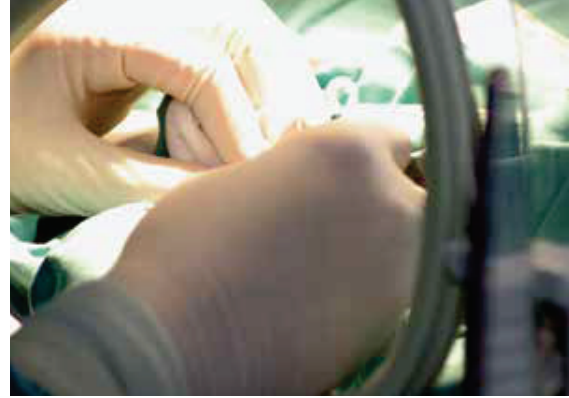
### What is vortices technology?<sup>10,12</sup>

The patented Infant Flow LP generator is a new form of variable flow that uses vortices technology to reduce the imposed WOB during inhalation. Similar to the single-jet technology, the flow entrainment reduces the WOB on inhalation by meeting the patient's inspiratory flow demand and during exhalation gas flow flips away from the patient reducing resistance.

Four low-momentum jets (*two per nare*) impinge inside the generator to create a consistent and measurable positive airway pressure within the generator head. During inhalation, the dual jets entrain flow to meet the patient's inspiratory demand. During exhalation, the jets easily deflect to disrupt the gas flow. This disruption of flow creates vortice shedding that spirals outwardly, combining with the exhaled breath to create an organized, efficient flow path toward the exhaust ports.



## Self assessment



1. Describe RDS: \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

2. List three indications for nCPAP therapy:\_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

3. List three benefits of nCPAP therapy: \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

4. List three potential complications to nCPAP therapy:
- 
- 
- 

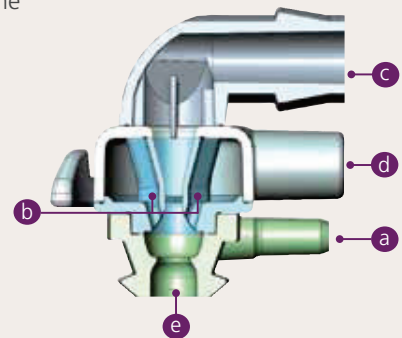
5. State four methods used to deliver nCPAP therapy:
- 
- 
- 
- 

6. Discuss the advantage of variable flow technology compared to other CPAP modalities: \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

7. Discuss the importance of low work of breathing:
- 
- 
- 
- 

8. Match the generator parts to the diagram:

- \_\_\_\_\_ Pressure line
- \_\_\_\_\_ Impinging jets
- \_\_\_\_\_ Exhaust tube
- \_\_\_\_\_ Drive line
- \_\_\_\_\_ Patient



**Notes:** \_\_\_\_\_



# Infant Flow SiPAP driver overview



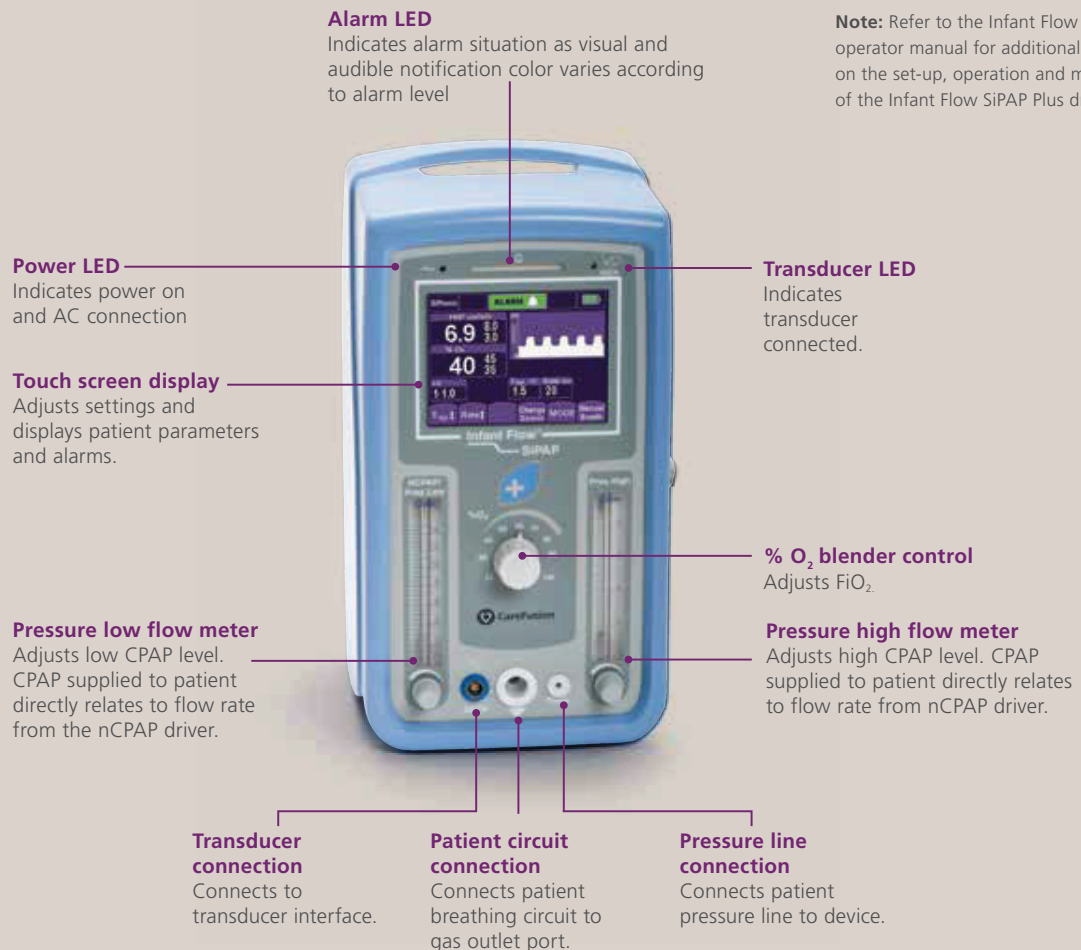
## Infant Flow LP system

The Infant Flow LP nCPAP system is a comprehensive system for delivering unique nCPAP therapy.

The system consists of:

- Infant Flow SiPAP driver
- Infant Flow LP generator assembly
- Infant Flow LP fixation—bonnet or headgear
- Infant Flow LP nasal interfaces—mask or prongs









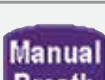











This chapter discusses the set-up and operation of the Infant Flow SiPAP Plus driver.



## Infant Flow SiPAP configurations

The Infant Flow SiPAP driver is sold globally and is available in different configurations. The two main models are Infant Flow SiPAP Plus and Infant Flow SiPAP Comprehensive. The Comprehensive model offers an additional ventilation mode, BiPhasic trigger, which is not available in the U.S.

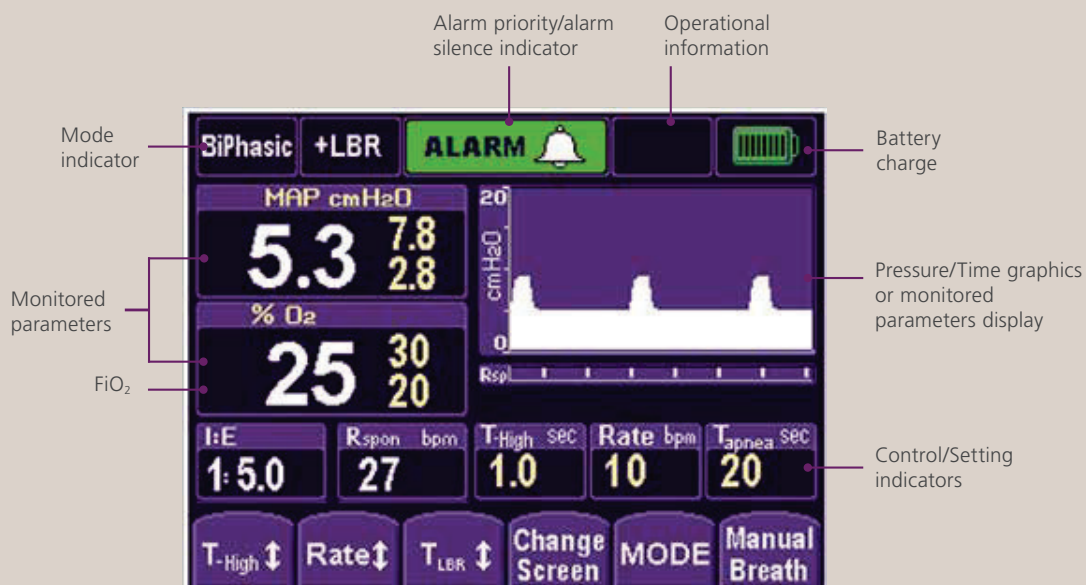
In select areas, additional languages or an international icon overlay may be used in place of the English text. The operation and maintenance of the Infant Flow SiPAP driver is the same regardless of the specific configurations. Refer to the Infant Flow SiPAP operator manual for more specific details.

Description	English text	ICON symbol
Press to access the user calibration menu and language options.*		
Press to return to the start-up screen.		
Press to switch between the graphical and numerical monitoring screen.		
Press to change the operation mode.		
Press to deliver a manual breath. The breath delivers at the pressure high setting for the set time high duration.		
Indicates user should refer to the operator manual for additional information.	 Read Manual	
Indicates battery status and turns red if the battery charge is less than 40%.		
Indicates the screen is locked. Press to unlock the screen.		
Adjust the low flow rate setting for the baseline CPAP level.		
Adjust the high flow rate setting for BiPhasic high CPAP level.		

\*Language option not available on all SiPAP models.

## Infant Flow SiPAP display screen

### Mode, control settings and function buttons



Soft key color code	
White letter	
Key enabled	
Faded letter	
Key inactive	
Yellow letter	
Solid: Pending confirmation Flashing: Low-priority alarm	
Red letter	
Flashing: High-priority alarm Solid: Reduction in another parameter caused by an adjustment	

Alarm management	
High priority	<ul style="list-style-type: none"> <li>Series of 10 tones sound every 10 seconds</li> <li>Parameters display, and limits flash red</li> </ul>
Medium priority	<ul style="list-style-type: none"> <li>3 audible tones sound every 15 seconds</li> <li>Parameters display, and limits flash yellow</li> </ul>
Low priority	<ul style="list-style-type: none"> <li>2 audible tones sound every 30 seconds</li> <li>Parameters display, and limits change to yellow</li> </ul>

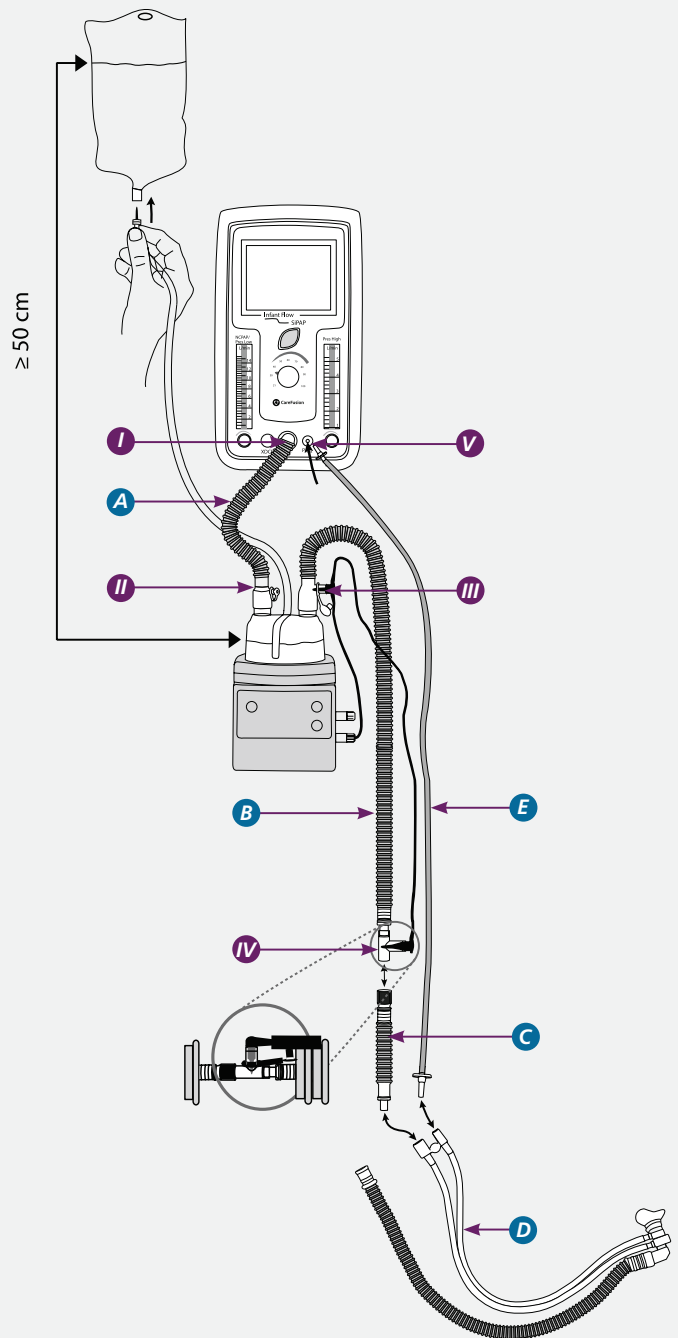
## Infant Flow SiPAP and circuit set-up

### Circuit set-up

1. Gather the nCPAP supplies:
  - Infant Flow SiPAP driver
  - Single-limb, heated breathing circuit
  - Infant Flow LP generator kit
  - Infant Flow LP fixation device
  - Humidifier and chamber
  - Sterile water bag
2. Attach the water chamber to the humidifier and connect it to the water feed system. Follow the manufacturer instructions for the proper set-up.
3. Connect the gas delivery tubing (A) to the flow driver outlet port (I) and humidifier chamber port (II).
4. Connect the elbow connector on the heated breathing circuit (B) to the humidifier chamber. Insert the heater wire plug into the wire socket. Securely insert the temperature probe in the port on the circuit elbow (III). Insert the second temperature probe (IV) into the airway port at the distal end of the breathing circuit.
5. Connect the non-heated section (C) to the drive line of the generator assembly (D).
6. Connect the proximal pressure line (E) to the proximal port on the driver (V) and the pressure line on the generator.

### Temperature probe

When inserting the temperature probe into the circuit, ensure the probe tip is in the middle of the gas stream. This allows the gas temperature to be measured accurately. If the probe is not properly seated, the temperature measurement accuracy may be compromised, leading to excessive condensation. Cover the temperature probe with a reflective shield when used under a radiant warmer or bilirubin light.



## Humidification and nCPAP

### Humidification

Heated humidification is recommended for nCPAP therapy. The normal functions of the nose and air passages of the respiratory tract are too warm, moisten and filter the inhaled gases before they reach the lungs. In normal respiration, the nasal mucosa and upper airways provide 75% of the heat and moisture supplied to the smaller airways and alveoli. By the time air reaches the alveoli, the inspired gas warms to 37 °C at 100% relative humidity (RH).<sup>13</sup> With nCPAP, the upper airways are not bypassed, but the high gas flows may be drying to the airways, especially to a neonate's underdeveloped lung. Adequate humidification is essential to maintain airway clearance, optimize ventilation and improve patient comfort.

The International Organization for Standardization (ISO) and American Association for Respiratory Care (AARC) clinical

practice guidelines recommend gas temperature between 34 and 41 °C to provide a humidity level of 33 to 44 mgH<sub>2</sub>O/L with artificial airways.<sup>14</sup> Be cautious using higher temperatures, as condensation may reduce the mucous viscosity and interfere with the mucous clearance. Extended exposure of gas temperatures over 41 °C may cause cellular damage to the airways.<sup>14</sup>

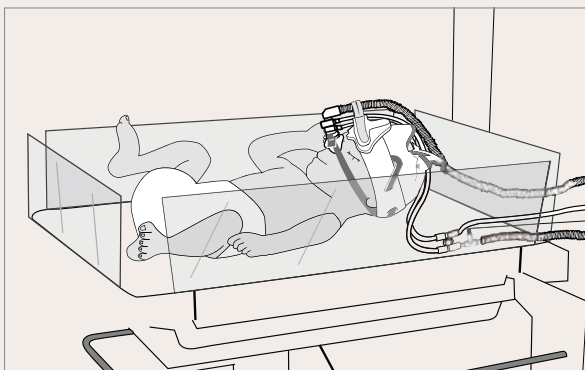
The higher temperature settings may not be required to deliver adequate humidification, since an artificial airway is not used with nCPAP. Start with a temperature setting of 36 °C to 37 °C and adjust the humidifier settings to maintain adequate humidification; if condensate occurs, reduce the humidifier temperature setting.

## Airway temperature probe placement

### Open bed or crib

When the infant is placed on an open bed warmer or crib, it is recommended to remove the unheated section. This places the temperature probe next to the generator assembly.

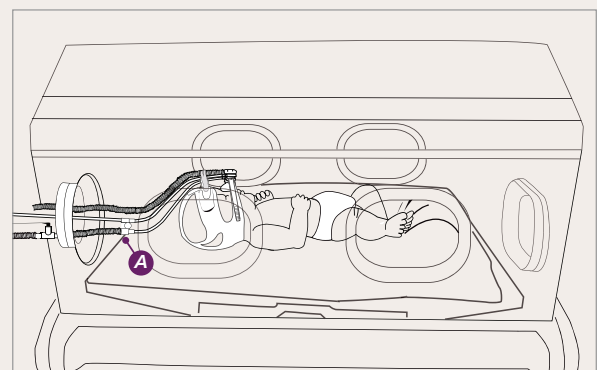
If the infant is under a radiant warmer or bilirubin light, the temperature probe should be covered with a light reflective shield to prevent heating the probe. If the probe is not covered, it could interfere with the operation of the humidifier and cause excessive condensation to form.



### Isolette or incubator

When the infant is in an isolette or incubator, the non-heated section should be used with the temperature probe placed outside of the isolette. Make sure that the rest of the unheated section remains in the isolette.

If condensation is observed, remove the non-heated (A) section and place the temperature probe inside the isolette.




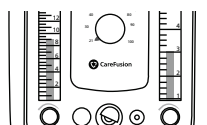


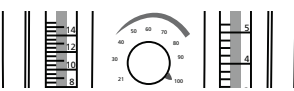






## Infant Flow SiPAP sensor calibration

### Two-point oxygen sensor calibration

Two-point oxygen sensor calibration should be performed before initially using the Infant Flow SiPAP driver and with each circuit change. To avoid unwanted alarms, occlude the prongs or mask and set the low pressure flowmeter to

9 LPM prior to turning on the Infant Flow SiPAP driver on. When the Infant Flow SiPAP driver is turned on, a power on self-check automatically performs.

To perform two-point calibration:	
1. Press the CAL button to enter the calibration menu.	
2. Set the pressure low flowmeter to 9 LPM and the pressure high flowmeter to 2 to 3 LPM. <b>Note:</b> The pressure high flowmeter must be set during set-up to enable the manual breath button.	
3. Adjust the oxygen control to 21%. Allow time for the reading in the oxygen display window to stabilize.	
4. Press the flashing question mark button located under the 21% icon. The question mark changes to a static hourglass. When calibration is complete, a static green check mark icon appears and the oxygen display window reads 21%.	
5. Adjust the oxygen control to 100%. Allow time for the reading in the oxygen display window to stabilize.	
6. Press the flashing question mark button located under the 100% icon. The question mark changes to a static hourglass icon. When calibration is complete, the hourglass icon changes to a static checkmark. The oxygen display window reads 100%.	
7. If oxygen calibration fails, a red X displays on the button of the screen, the alarm sounds and an Error code displays on the top-left corner. Turn the driver off and then, back on. Repeat the calibration procedure.	
Disable the oxygen sensor	
The internal oxygen sensor may be disabled by pressing the O <sub>2</sub> disable button on the calibration screen. This disables oxygen monitoring and the audible oxygen alarm. An error code displays to indicate the oxygen monitor is inoperative. An external oxygen monitor must be used whenever the oxygen sensor is disabled.	
Leak test	
While occluding the patient interface, set a flow of 9 LPM on the pressure low flowmeter. A CPAP of 5 cmH <sub>2</sub> O ± 1 should display on the SiPAP screen. If pressure is not reached, check the system for leaks. Release the occlusion, and the displayed pressure should be ≤ 2 cmH <sub>2</sub> O. Wait for 15 seconds, and a disconnect alarm should sound. If the pressure does not fall, check the circuit for occlusions.	

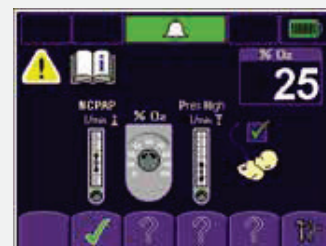
## Infant Flow SiPAP set-up guide

### Set-up menu screen

1. Adjust the pressure low flowmeter until the desired nCPAP pressure displays on the screen. Press the flashing question mark icon, which changes to a static checkmark to confirm the setting.
2. Adjust the oxygen control dial to set the desired  $\text{FiO}_2\%$ . Press the flashing question mark icon. A checkmark appears to confirm the setting.
3. Adjust the pressure high flowmeter until the pressure displays 2 to 3  $\text{cmH}_2\text{O}$  above the set nCPAP pressure. Press the flashing question mark icon. A static checkmark appears to confirm the setting.
4. To use the low breathing rate/apnea monitor, connect the transducer interface to the Infant Flow SiPAP driver. Press the flashing question mark under the infant respiratory sensor icon. This will change to a static checkmark to confirm the setting. This does not confirm that you want to use the respiratory monitoring option but ensures that all modes are available for later use.
5. After completing the above steps, the screen changes and displays the nCPAP mode. The infant can now be connected to the Infant Flow SiPAP system.

### Alarm set/confirm screen

Press the nCPAP button or alarm bar for three seconds to set the alarm limits and move to the next screen. If no button is pressed within two minutes, the alarm limits automatically set and the screen changes to the mode select screen.



Set-up menu screen



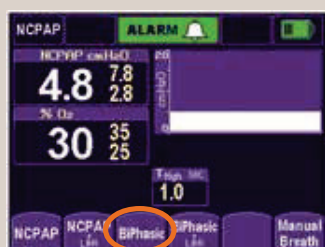
Alarm set/confirm screen

### Mode select screen

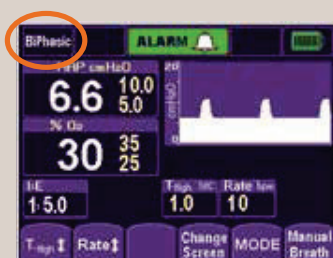
All available modes display at the bottom of the screen.

1. For low breath rate/apnea modes, attach the abdominal respiratory sensor to the transducer and properly place it on the infant's abdomen.
2. Select the desired mode of operation by pressing the corresponding button (*mode select screen*). The parameter adjust screen displays, and the new mode displays in the upper-left corner (*parameter adjust screen*).

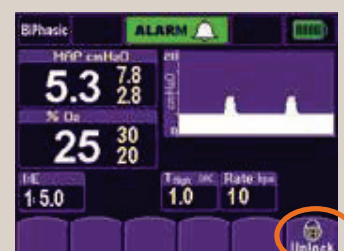
3. Make the desired setting changes, and press the selected mode to confirm the settings and activate the new mode.
4. If no selection is made within two minutes and no alarms sound, the screen locks to prevent entries. The mode buttons go blank, except for the last button on the right (*locked screen*). To unlock the screen, press the lock icon.



Mode select screen



Parameter adjust screen



Locked screen

## Infant Flow SiPAP set-up guide (*continued*)

### Parameter adjust screen

1. To change the settings during set-up and normal operation, touch the desired parameter button.
2. Press the up or down arrows to adjust the parameter to the desired setting.
3. Confirm the change by re-pressing the parameter button. The main screen displays.

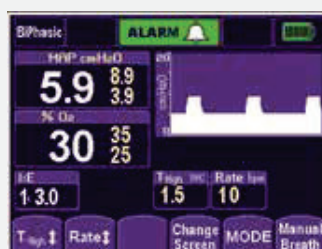
**Note:** nCPAP and BiPhasic pressure levels are set by adjusting the flow.



Parameter adjust screen

### Main screen and monitored parameter screen

1. To monitor therapy, use the main screen or monitored parameter screen. The main screen graphically displays the delivered pressure. The monitored parameter screen displays numerical values for the delivered pressure.
2. Press the Change Screen button to switch the screen display.



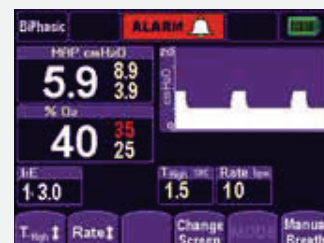
Main screen



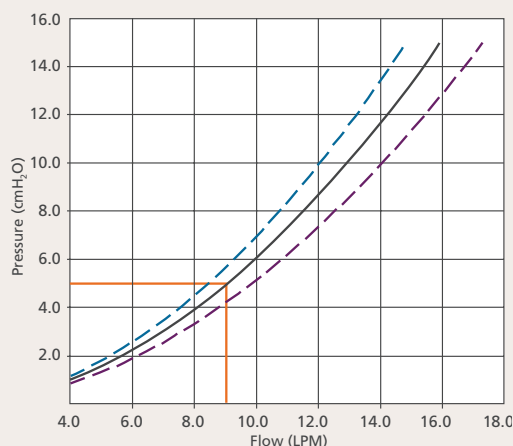
Monitor parameter screen

### Alarm reset/silence

1. Press the alarm bar to silence the active alarms for 30 seconds.
2. Press the alarm bar for three seconds to clear resolved and low-priority alarms and to reset alarm limits. Smart alarm technology automatically sets high pressure, low pressure and % oxygen thresholds.



Main screen with active alarm



### Flow pressure nomogram

The Infant Flow SiPAP LP system is subject to a direct relationship between the controlled gas flow and airway pressure. For example, 9 LPM of gas flow provides approximately 5 cmH<sub>2</sub>O CPAP.

**Tip:** Manual breath: The high pressure flowmeter must be set to deliver a manual sigh/breath during CPAP. The boost in pressure delivers for the time high that was entered during the set-up process.

## Respiratory abdominal sensor

### Respiratory abdominal sensor (optional)

For use only with the Infant Flow SiPAP Plus and Comprehensive nCPAP drivers. The respiratory abdominal sensor enables the clinician to monitor for apnea/low breath rate in both nCPAP and BiPhasic modes. The accessories include the reusable transducer and single-patient-use abdominal sensor. In the BiPhasic trigger mode, the respiratory abdominal sensor and transducer allow patient-triggered pressure assists with breath rate monitoring (*not available in the U.S.*).

### Respiratory transducer connection

1. Connect the transducer cable to the transducer port on the front panel.
2. Connect the abdominal sensor pressure line to the transducer interface.
3. Compress the sensor pad gently, repeating this several times while observing the transducer LED.

### Infant set-up

To apply the sensor to the infant using suitable tape (*figure 1*):

1. Visually identify the optimum outward movement of the abdomen during inspiration. When the infant

breathes, the most movement is between the lowest rib and the abdomen.

2. If the infant is supine, place the capsule midway between the umbilicus and xiphisternum, which is the notch at the center of the two lower ribs. On larger infants, an alternative site is the upper chest to detect intercostal movement.
3. If the infant is prone, place the sensor laterally over the lower rib and abdomen. The sensor tubing should be directed over the back.
4. Tape the sensor firmly into position using a non-allergenic microprobe tape. Position the sensor line perpendicular to the tape. Only use tape that is approved by your facility's protocol.
5. Verify correct placement. The transducer LED should illuminate on expiration, and the SiPAP front panel LED on inspiration.
6. If the LED does not illuminate, try repositioning the sensor and adding a second piece of tape making an "X" over the sensor.

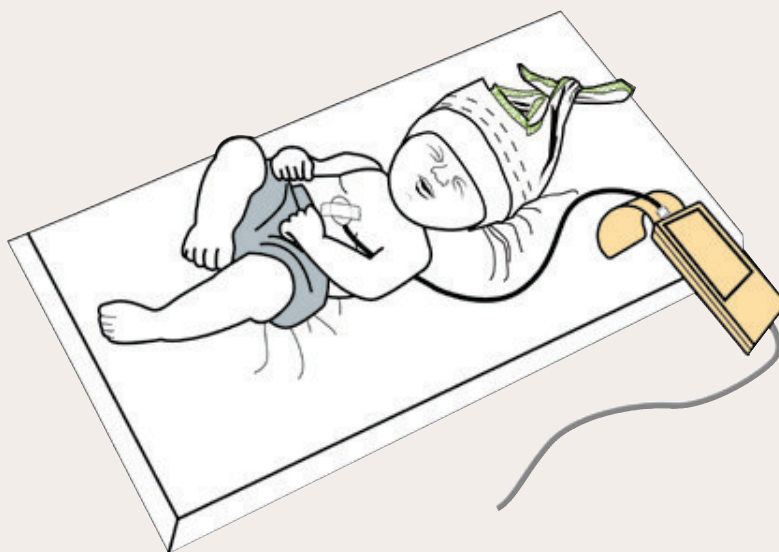


Figure 1: Abdominal sensor placement

## Self assessment



1. Where should the circuit airway temperature probe be placed if the infant is in an isolette/incubator? \_\_\_\_\_

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2. If condensation occurs in the breathing circuit, what should you do?

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3. Explain how to disable the oxygen sensor: \_\_\_\_\_

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4. Demonstrate how to reset the alarm limits when the device is in operation: \_\_\_\_\_

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5. To deliver a CPAP of 5 cmH<sub>2</sub>O, what would the flow rate be?

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6. Where is the best placement for the respiratory abdominal sensor? \_\_\_\_\_

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7. While in nCPAP, you press the manual breath button, but nothing happens. What would prevent a manual breath from being delivered? \_\_\_\_\_

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8. When should you perform an oxygen sensor calibration on the Infant Flow SiPAP? \_\_\_\_\_

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**Notes:** \_\_\_\_\_

[illegible]



# Infant Flow SiPAP nCPAP driver



## Modes of operation

### nCPAP mode

nCPAP mode delivers constant, stable positive pressure to infant airways to help restore the FRC in assisting the correction of hypoxemia. Adjust the flow rate setting to deliver CPAP up to 11 cmH<sub>2</sub>O.

CPAP parameters:

- CPAP pressure (*set by low pressure flowmeter*)
- Oxygen percentage

Initial settings:

- CPAP 4 to 6 cmH<sub>2</sub>O

### nCPAP + low breath rate (LBR)/Apnea

The mode allows the delivery of CPAP pressures up to 11 cmH<sub>2</sub>O and breath rate monitoring via respiratory abdominal sensor and transducer interface. For the SiPAP Plus system, the LBR setting is determined by LBR time (TLBR) setting from 10 to 30 seconds. For the SiPAP Comprehensive system, the Apnea setting is determined by the apnea time (T-apnea) setting from 10 to 30 seconds. If the apnea alarm is triggered, the device delivers one breath at the high pressure setting. The high pressure flowmeter must be set.

### BiPhasic mode

This mode cycles between high/low CPAP levels on a timed basis. Small incremental pressure increases of 2 to 3 cmH<sub>2</sub>O above CPAP creates a "sigh" breath, and augments FRC and decreases WOB. The switch to the high CPAP level can

be set for a duration of 0.1 to 3 seconds to produce a "sigh."

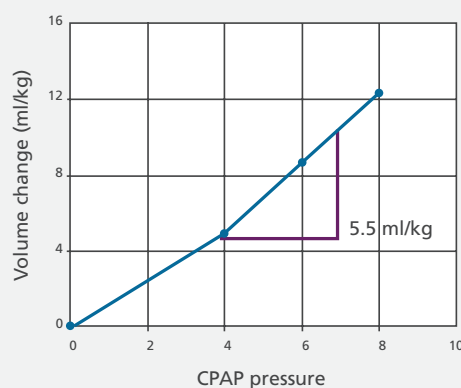
**Note:** This is not the same as pressure support. In pressure support, the pre-set pressure supports the inspiratory effort and the patient's breathing pattern determines the inspiratory time. In the BiPhasic mode, the infant can breathe spontaneously at either pressure level. The time high setting determines the cycle time between the two levels of CPAP.

BiPhasic parameters:

- Baseline CPAP (*set by low pressure flowmeter*)
- High CPAP (*set by high pressure flowmeter*)
- Time high (T-high)
- Rate (*cycle rate between pressures*)
- Oxygen percentage

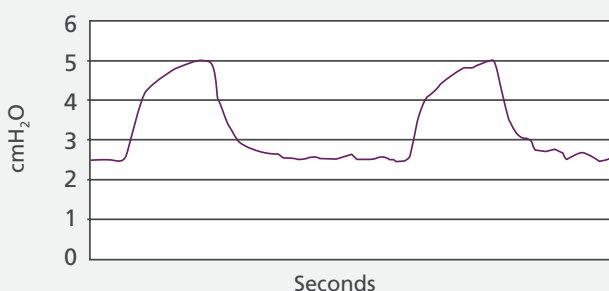
Initial settings based on respiratory conditions:<sup>9</sup>

- Baseline CPAP 4 to 6 cmH<sub>2</sub>O
- Pressure high (PHigh) 1 to 3 cmH<sub>2</sub>O above CPAP level
- T-high 1.0 sec
- Rate 6 cycles/minute



In this study, a 3 cmH<sub>2</sub>O shift in pressure on an average increased FRC by 5.5 mL/kg.

Pandit, P. Pediatric, 2001, 108(3):682-685.



### BiPhasic + LBR/apnea mode

This mode is the application of BiPhasic therapy with low breath rate detection via the respiratory abdominal sensor and transducer interface. For SiPAP Plus, the LBR setting is determined by the TLBR setting from 10 to 30 seconds. For SiPAP Comprehensive, the Apnea setting is determined by T-apnea setting from 10 to 30 seconds.

### SiPAP Comprehensive BiPhasic tr\* mode

This mode utilizes the respiratory abdominal sensor and transducer interface to synchronize pressure high breaths with the infant's respiratory efforts. It allows patient-triggered pressure assists with breath rate monitoring enabled, adjustable apnea time interval, apnea alarm and adjustable apnea backup rate. The upper level pressure delivers based on operator set T-high and PHigh flow rate settings. The maximum pressure setting is 15 cmH<sub>2</sub>O. If the respiratory efforts are not detected, the infant receives the low CPAP setting and the apnea alarm initiates the delivery of the set backup rate.

BiPhasic tr parameters:

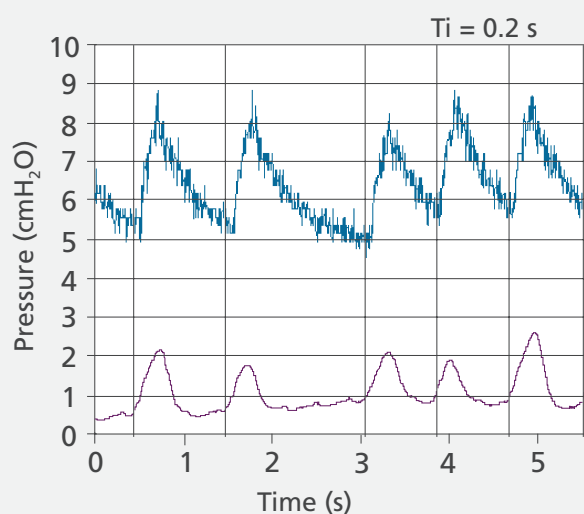
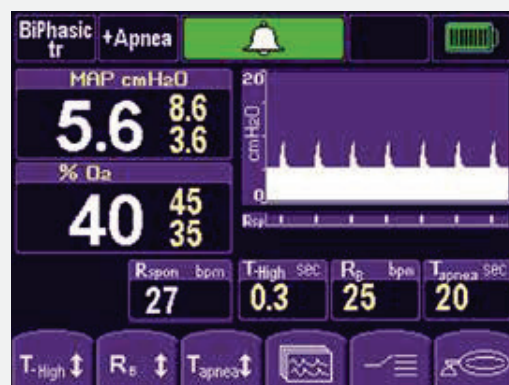
- Baseline CPAP (*set by low pressure flowmeter*)
- Peak inspiratory pressure (PIP) (*set by high pressure flowmeter*)
- T-high
- Backup respiratory rate
- Apnea time
- Oxygen percentage

Initial settings: Initial settings should be tailored to the infant's respiratory condition.

- Baseline CPAP at clinical indicated level (*4 to 6 cmH<sub>2</sub>O*)
- PIP: 2 to 3 cmH<sub>2</sub>O above set CPAP level. Set by the PHigh flowmeter.
- T-high:  $\leq 0.3$
- Rate (Rb): Set rate is active only if Tapnea (sec) threshold is surpassed. Generally, set it close to the infant's own respiratory rate.
- Apnea time (*tapnea*): 10 to 30 seconds. The apnea alarm triggers when no breaths are detected within the selected apnea timeout.

Timed BiPhasic breaths are given at the set backup rate, PHigh and T-high. If the infant triggers within the next time-out period, the alarm silences and triggered-BiPhasic resumes.

If no breaths are detected after the next apnea timeout, the audible alarm resumes until the operator intervenes.



\*BiPhasic tr mode available in comprehensive configurations only. Not available in the U.S.

## BiPhasic mode strategy

### SiPAP settings

SiPAP is a strategy that assists infants who are spontaneously breathing yet require some assistance. The theoretical benefits of the SiPAP strategy are that the sigh cycles may recruit unstable alveoli (*or prevent their collapse*), offload the respiratory work, stimulate the surfactant release and stimulate the respiratory center drive.

The BiPhasic mode parameters may change depending on the infant's respiratory status and condition.

After initiating the therapy, monitor the infant's oxygen and ventilation status. Adjust the settings to provide necessary respiratory support as the infant's condition changes.

### Strategy to improve oxygenation

- Increase CPAP low level
  - Increases FRC
- Increase duration T-high (*maximum setting is three seconds*)
  - Improves alveolar recruitment
- Increase FiO<sub>2</sub>

### Strategy to improve ventilation and oxygenation

- Increase Delta P between CPAP and PHigh CPAP (↑PHigh), which:
  - Augments tidal volumes
  - Offloads more WOB
  - Decreases PaCO<sub>2</sub>

- Increase rate, which:
  - Increases alveolar recruitment and ventilation
  - Offloads WOB
  - Decreases PaCO<sub>2</sub>

### Signs of positive response to nCPAP therapy

- Reduction in respiratory rate
- Stabilization or reduction in FiO<sub>2</sub>
- Resolution of grunting
- Reduction in the degree of sternal and intercostal recession
- Relaxation, not in opposition to therapy

**Tip:** Disconnect alarm: A minimum CPAP setting of 3.0 cmH<sub>2</sub>O is required to detect patient disconnect.

**Tip:** Baseline CPAP: Gas trapping may occur with inverse I:E ratio. Ensure a one-second minimum at the baseline CPAP.

**Tip:** Setting time high (T-high): The SiPAP flow system delivers a slow rise to the high pressure. If the T-high setting is too short, the high CPAP may not be reached. Consider increasing the T-high setting until the high CPAP level is obtained.

S. Courtney, MD, Neonatal and Perinatal Medicine, has suggested the protocol below for the application of SiPAP therapy.<sup>15</sup> This information is provided only as a guideline; refer to your facilities policies and procedures for nCPAP.

	Low CPAP	High CPAP (above low CPAP)	Time high	Cycle rate
Apnea	4–5 cmH <sub>2</sub> O	1–2 cmH <sub>2</sub> O	0.3–0.5 sec	10 cycles/min
Oxygenation	4–5 cmH <sub>2</sub> O	2–3 cmH <sub>2</sub> O	1.0 sec	20 cycles/min
Ventilation	4–5 cmH <sub>2</sub> O	≥ 3 cmH <sub>2</sub> O	0.5–3.0 sec	10–30 cycles/min

## BiPhasic mode strategy (*continued*)

### Strategy for weaning

- Ensure  $\text{FiO}_2$  requirements are less than 50%
- Slowly decrease the cycle rate  
Example: 20–15; 10–5
- Decrease the high CPAP to baseline CPAP
- Continue to monitor the infant's respiratory status and wean the infant from CPAP support as tolerated

### Indications of failure to nCPAP therapy<sup>3-6</sup>

- $\text{FiO}_2 \geq 50\%$
- Respiratory acidosis indicated by a  $\text{pH} < 7.28$  and  $\text{paCO}_2 > 50\text{mm Hg}$
- Development of recurrent apnea requiring stimulation
- Development of a pneumothorax
- Worsening sternal and intercostal recession/ grunt/tachypnea
- Agitation not relieved by simple measures such as comforting or light sedation
- Development of spontaneous episodes of significant desaturation ( $< 90\%$  for  $> 20\text{ sec}$ )

## History fun facts

- 2698-2699 BC: Huang-Ti, emperor, recorded sudden death from respiratory failure in neonates. He noted deaths to be more common in premature infants.
- 1543: Andreas Vesalius, father of ventilation, described tracheostomy, intubation and ventilation to maintain life.
- 1879: Gairal, French obstetrician, created the aerophore pulmonaire for intermittent positive-pressure ventilation of infants.
- 1896: Joseph De Lee described warning signs of fetal distress, recommending to “supply air to lungs for oxygenation.”
- 1914: A. Von Reuss described using CPAP to resuscitate newborn infants with an oxygen tank, mask and water bottle.
- 1963: H. Barrie described a “bubble” pressure apparatus with tubing inserted to 40 to 50  $\text{cmH}_2\text{O}$ .
- 1971: George Gregory delivered CPAP via an endotracheal tube (ET tube) to treat spontaneously breathing neonates with RDS.
- 1975: Kattwinkel delivered CPAP using binasal prongs.

### CareFusion history

- 1988: Moa and Nilsson introduced the single-jet variable flow nCPAP using fluidics via a generator and binasal prongs.
- 1991: The first commercial Infant Flow generator was released.
- 1993: The first EME Infant Flow nCPAP driver was introduced.
- 2000: The Infant Flow Advance with a BiPhasic trigger mode was launched.
- 2001: The swivel connector was added to the Infant Flow generator, and the bonnet design was changed.
- 2004: The Infant Flow SiPAP driver with Simple Touch operation and advance patient monitoring were introduced.
- 2006: The AirLife® nCPAP dual-jet variable flow generator with headgear and anatomically designed interfaces were introduced in the U.S.
- 2011: The Infant Flow low pressure generator was launched globally.

## SiPAP exercises and self assessment



### Exercise No. 1

Attach the SiPAP circuit, and occlude the nasal prongs. Enter these settings on the SiPAP driver:

- Set low pressure flow rate at 9 LPM
- Set high pressure flow rate at 2 LPM
- Set  $\text{FiO}_2$  at 21%
- Go to nCPAP mode screen

1. What is the nCPAP value? \_\_\_\_\_
2. Press the manual breath button. What pressure was delivered? \_\_\_\_\_
3. How long did the breath remain at the high CPAP? \_\_\_\_\_
4. Set the T-high to 1.0 seconds, and press the manual breath button. What happened? \_\_\_\_\_  
\_\_\_\_\_

### Exercise No. 2

Switch from the nCPAP mode to the BiPhasic mode, and enter the settings:

- Low pressure flow rate at 9 LPM
- High pressure flow rate at 2 LPM
- $\text{FiO}_2$  at 21%
- Rate of 20
- T-high at 0.3 seconds

1. What is the MAP? \_\_\_\_\_
  2. Switch from the graphic screen to the parameter screen.  
What is the PIP? \_\_\_\_\_  
What is the CPAP level? \_\_\_\_\_
  3. Increase the T-high to 15 seconds.  
What is the PIP? \_\_\_\_\_  
What is the MAP? \_\_\_\_\_
- Discuss why these values changed. \_\_\_\_\_

### Exercise No. 3

In BiPhasic mode, enter these settings:

- Low pressure flow rate at 9 LPM
- High pressure flow rate at 2 LPM
- $\text{FiO}_2$  at 21%
- Rate of 20
- T-high at 2 seconds

1. Increase the rate to 30. What happens to the T-high? \_\_\_\_\_
2. Increase the T-high back to 1.5 seconds. What happens to the rate? \_\_\_\_\_
3. Discuss why these values changed: \_\_\_\_\_





# Infant Flow LP generator assembly



## Infant Flow LP generator

The Infant Flow LP nCPAP system features a dual-jet generator that incorporates fluidic technology. The low-momentum impinging jets effectively reduce patient's WOB during inspiratory and reduces resistance to expiratory efforts. The low pressure refers to the driving pressure. Compared to other variable flow devices, the Infant Flow LP generator utilizes 80% less driving pressure on average to create the same pressure level at the patient nares.

The generator head contains four impinging jets, two per nare, and connects the nasal interface, fixation device and exhaust tube. The quick secure tab enables a fast connection of fixation straps to the generator head.

The exhaust tube redirects excessive air flow away from the infant and clinician. The first part of the exhaust tube is corrugated to provide more flexibility in positioning the exhaust tube. When in use, the corrugate should be fully expanded.

The exhaust vent features two small slits on the exhaust tube that allow gas flow to vent to the atmosphere should the end of the exhaust tube become blocked or kinked.

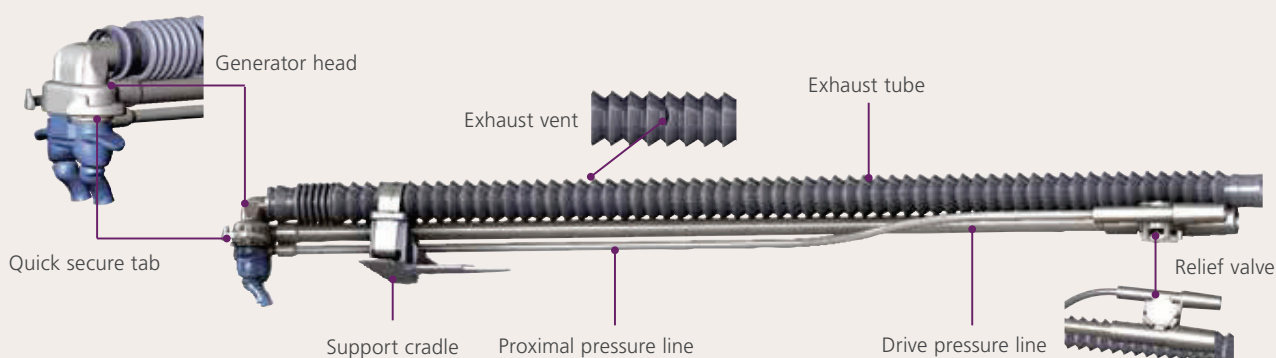
The support cradle stabilizes the generator assembly and helps maintain proper alignment with the nasal area. This reduces the incidence of the nasal prongs dislodging or the mask leaking during infant movement.

The proximal pressure line connects with the circuit pressure line to enable monitoring the pressure delivered directly to the patient interface. The drive line connects with the breathing circuit to deliver gas flow to the generator.

The pressure relief valve provides secondary safety pressure for the driving pressure. The threshold for the relief valve is significantly lower than the SiPAPs internal pop-off.

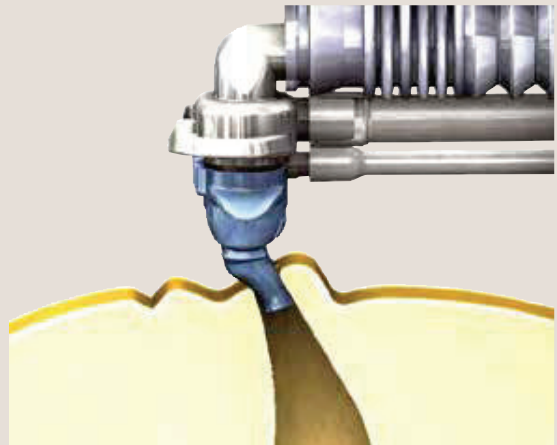
### Material content

The generator assembly does not contain latex or Bisphenol A (BPA). All of the Infant Flow LP components are manufactured without the use of phthalates, such as DEHP.



## Infant Flow LP interfaces

The nasal interface is key to the successful delivery of nCPAP. An effective seal means fewer leaks, a consistent level of nCPAP and decreased nuisance alarms for the clinician for less disturbance to the infant during recovery. The Infant Flow LP interface features soft, comfort-fit prongs and masks that provide an effective seal and minimize the potential for skin necrosis. The Infant Flow LP interfaces are available in five sizes to fit your infant's needs. The masks and prongs do not contain latex or Bisphenol A (BPA). The components are manufactured without the use of phthalates, such as DEHP.



## Infant Flow LP prongs

**High profile design:** The base of the prongs help minimize contact with the skin and provide visual verification for proper placement. The base should be clearly visible outside of the infant's nares. The design limits contact with the infant's skin, reducing the risk of necrosis.

**Septal relief:** A recessed area between the prongs reduces pressure on the infant's septum, minimizing skin necrosis in this delicate area.

**Flexible bellow:** Between the prongs and the base, flexible bellows allow each prong to move independently for a custom fit that provides comfort and minimizes leaks.

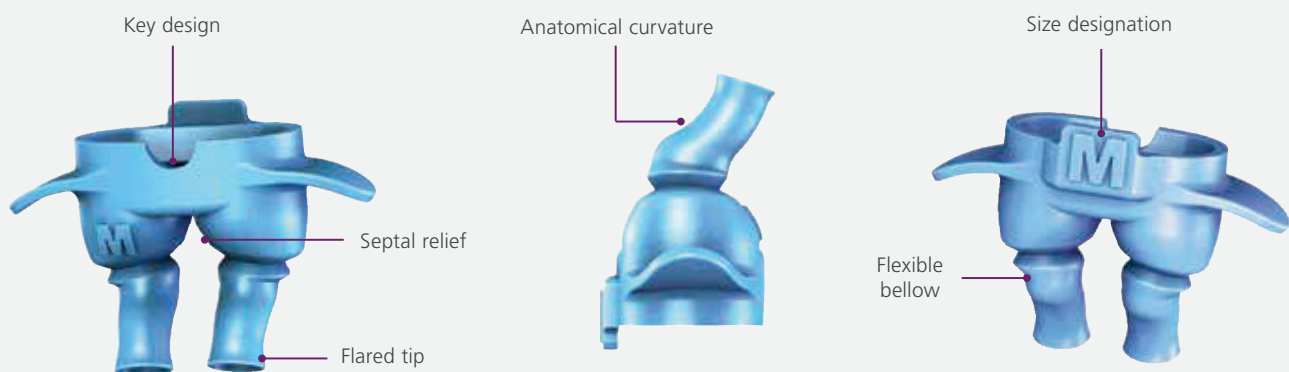
**Flared tip:** The ends of each prong are gently flared to help form an effective seal and minimize leaks.

**Anatomically correct curvature:** The prongs are designed to follow the natural contours of the infant's nares.

**Appropriate prong length:** The length of the prongs helps maintain an effective seal during periods of movement.

**Size designation:** The prongs are color-coded, and the size is clearly indicated on the base tab for quick and easy size identification.

**Key design:** The base is keyed to fit the generator receiver above the pressure monitoring and drive lines.



Infant Flow LP mask

**Flexible bellow:** Between the mask body and the generator connection, a flexible bellow allows the mask to find a natural position over the infant’s nose, which helps minimize leaks and maintain a consistent nCPAP level. The floating seal minimizes pressure points and naturally moves with the patient.

**Variable wall thickness:** The mask is designed with variable thickness in the wall material to help retain its shape while limiting potential pressure points.

**Eye relief:** Contoured sides help maintain a proper fit and seal around the eyes.

**Key design:** The base is keyed to fit the generator receiver above the pressure monitoring and drive lines.

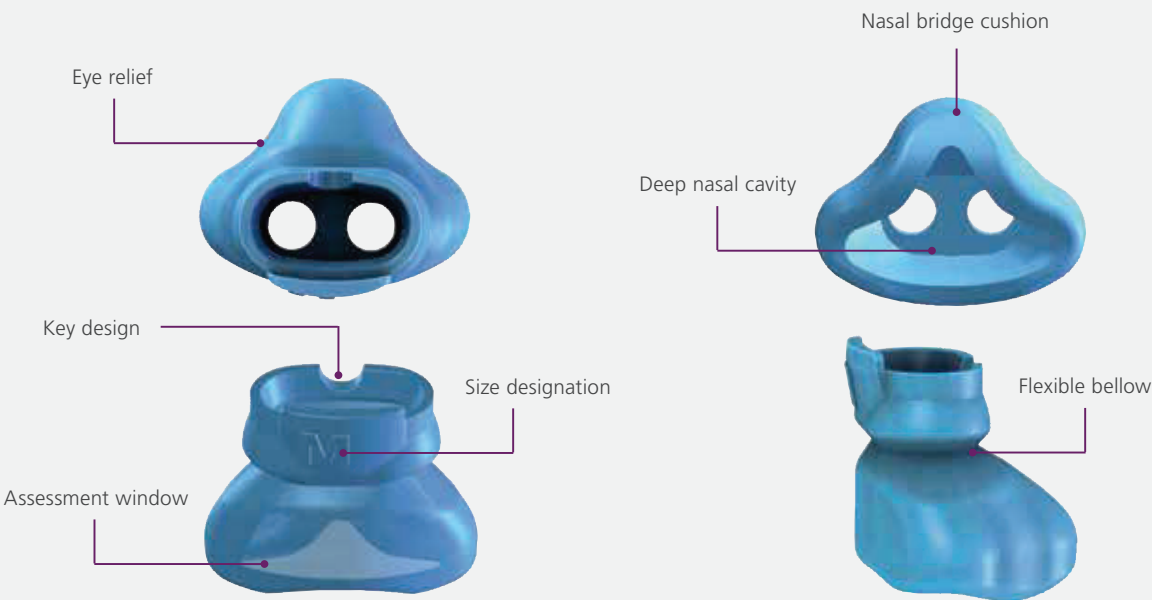
**Anatomically sized mask:** The mask allows ample room for the infant’s nose that minimizes pressure points and helps ensure patient comfort.

**Nose bridge cushion:** This area of the mask is cushioned to help decrease pressure points and increase patient comfort.

**Assessment window:** The clear section on the bottom of the mask allows the clinician to view the patient’s septum and nares to verify a proper fit.

**Size designation:** The mask is color-coded, and the size is clearly indicated on the base tab for quick and easy size identification.

**Deep nasal cavity:** A large nasal cavity accommodates various nasal shapes and reduces pressure points.



Nasal prongs	Color sizing		Nasal masks
	Extra small	Green	
	Small	Red	
	Medium	Blue	
	Large	Purple	
	Extra large	Clear	

## Infant Flow LP fixation devices

Properly placing the nCPAP fixation device on the patient is essential for delivering effective therapy. Applying excessive or uneven pressure can result in necrosis to the infant's skin and potentially inhibit recovery. The Infant Flow LP nCPAP

system offers two fixation options. The familiar soft cotton bonnets and patented comfort-wrap headgear secures the generator quickly and easily while minimizing pressure points.

### Comfort-wrap headgear

**Intuitive design:** The intuitive comfort wrap design allows a single clinician to secure the generator and helps minimize infant discomfort. Rather than pulling the device down over the infant's head, the clinician gently wraps the headgear around the infant's head and secures it with the adjustable straps for a custom fit. Six available sizes make size selection easy.

**Adjustability:** The design and placement of the fixation straps provide comfort and flexibility by keeping the device away from the infant's eyes. As the infant's head circumference changes, the headgear can easily be modified to adapt.

**Stabilization:** The comfort wrap design secures the generator at the proper angle, which aids in minimizing leaks.

### Bonnets

**Comfort soft:** The soft cotton offers a little stretch to conform to the infant's head and provide warmth.

**Open top:** Open at the top, the bonnet offers access to the scalp, allowing IV therapy, phototherapy and head ultrasound scans. Between therapies, the bonnet ends can be tied, covering the scalp and reducing heat loss.

**Stabilization:** The bonnet with the support cradle secures the generator at the proper angle, which aids in minimizing leaks.

**Size designation:** The tops of the bonnets are color-coded for easy size identification. The bonnets are available in 10 sizes to provide a comfortable fit.

#### Fixation tip

Periodically, at least every four hours:

- Reassess the fixation device for proper placement
- Check the generator and prongs for proper alignment
- Do not overtighten the straps





## Self assessment



1. What type of technology does the generator utilize?

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2. List three features of the generator: \_\_\_\_\_

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3. List three features of the nasal prongs: \_\_\_\_\_

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4. List three features of the nasal mask: \_\_\_\_\_

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5. Explain why the design of the fixation device and nasal interface is important: \_\_\_\_\_

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6. Match the interface color to the sizes:

- \_\_\_\_ Extra small                      a. Clear  
 \_\_\_\_ Small                                b. Purple  
 \_\_\_\_ Medium                              c. Green  
 \_\_\_\_ Large                                 d. Red  
 \_\_\_\_ Extra large                        e. Blue

**Notes:** \_\_\_\_\_

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

# Infant Flow LP patient set-up



## Infant Flow LP interfaces

Depending on the facility's protocol and the infant's need, either nasal prongs or nasal masks may be used with the variable-flow generator. Some protocols require the clinician

to routinely alternate between the nasal prongs and mask. The goal is to provide a good seal within and around the nose to deliver and maintain the desired nCPAP level.

### Nasal mask

The nasal mask provides an alternative to the nasal prongs. The mask is positioned over the infant's nose and forms a seal around the perimeter for the delivery of the prescribed CPAP level. To ensure a good fit and the ability to maintain the desired level of CPAP, use the sizing guide to choose the appropriate mask size.

#### Sizing guide (*figure 2*)

Use the nasal prong and mask sizing guide to select the mask that best fits the infant. Hold the triangle over the infant's nose, and select the triangle that encompasses the nasal area. **Note:** The size of the mask may differ from the prong size.

**Tip:** Go larger: If a patient falls between sizes, go larger. A mask that is too small may create pressure points on the nose and prevent a good seal from forming.

### Routine care

The clinician must select the correct size of the infant interface during the initial set-up, and continues to monitor and assess it throughout the treatment. Some infants may be on nCPAP therapy for several weeks, and the correct size of the interface may change. Re-evaluating the interface size is an important part of routine patient assessments. Attention to this detail reduces the potential for skin/septal injury and ensures that the prescribed CPAP level is achieved and maintained for optimal therapy.

### Nasal prongs

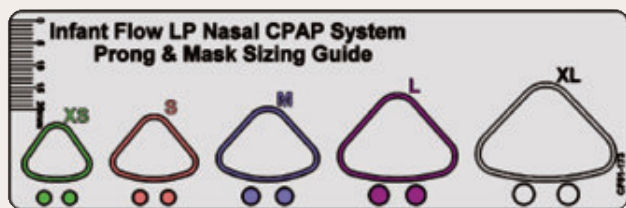
The nasal prongs consist of a pair of short tubes positioned directly in the infant's nares to deliver the prescribed CPAP level. The tip of the prong flares slightly as the gases pass through them, which helps form a seal within the infant's nares. The size of the nares vary with each infant and does not depend on the infant's weight, gestational age or body length. Five available sizes of nasal prongs cater to the individual differences.

#### Sizing guide (*figure 3*)

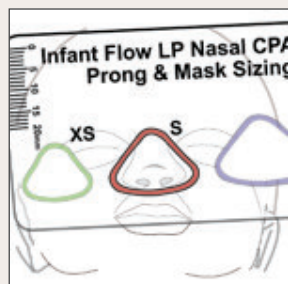
Use the nasal prong and mask sizing guide to select the prong that best fits the infant. To determine the correct prong size, position the dots on the sizing guide over the infant's nostrils. Choose the dots that best match the nostril's opening.

**Tip:** Go larger: If the infant is between sizes, select the larger size. If blanching of the nares occurs, go to the smaller size.

Prongs that are too small may lead a clinician to overtighten the fixation device to eliminate a leak. Overtightening or inserting the prongs too deep may lead to pressure sores or nasal dilation.

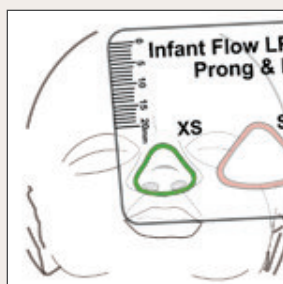


**Note:** The nasal prongs and nasal mask are single patient use and should be discarded at the end of therapy.



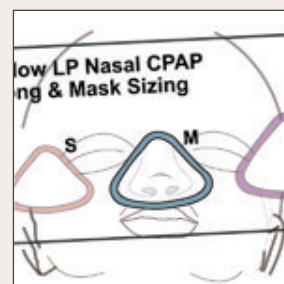
#### Correct size

If the outside of the triangle fits completely over the nasal area and below the eyes, the mask is the correct size.



#### Too small

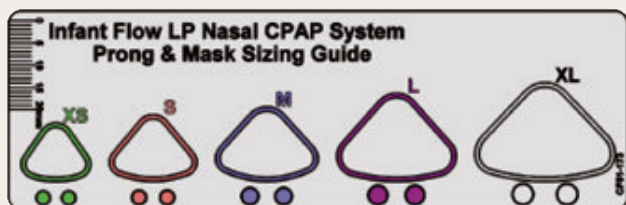
If the mask is too small, it may block the nares or rest uncomfortably against the patient's nose, causing pressure points.



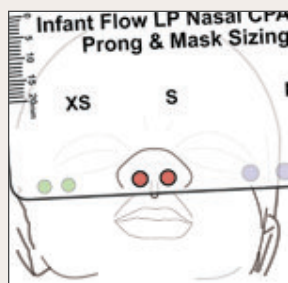
#### Too large

If the mask is too large, leaks may occur around the perimeter. The mask may rest on the infant's lip or sit too close to the eyes, causing discomfort.

Figure 2

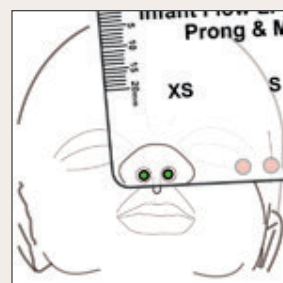


**Caution:** If the prongs are inserted into the nostril too far, the septum may be pinched between the prong base and septal irritation or damage could occur.



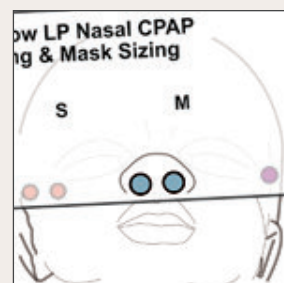
#### Correct size

The dots should completely fill the opening of the nares.



#### Too small

If the prongs are too small, an effective seal cannot form, which may affect CPAP delivery.



#### Too large

If the prongs are too large, the infant experiences discomfort and the nares may dilate.

Figure 3

## Fixation devices

The Infant Flow LP nCPAP system provides the clinician with two fixation options. Some clinicians may prefer the soft cotton bonnets for use with very low birth-weight infants or infants requiring frequent head scans. Some clinicians may prefer the unique headgear with adjustable straps to ease

application and quickly accommodate changes in the infant’s head size.

**Tip:** Fixation: The measurements for the bonnets and headgear are performed differently and therefore, are not interchangeable.

### Purpose of fixation devices

The main purpose of the fixation device is to keep the generator in a stable position. This is accomplished by using the correct fixation device and application technique. The practice of selecting the correct size and application technique is vital to ensure optimal nCPAP therapy. The correct application technique ensures:

- 1. Accurate measurement and sizing
- 2. Simplified fixation
- 3. Easier adjustments with minimal disturbance to the infant
- 4. Greater generator stability and fewer leaks
- 5. Improved comfort for the infant

Similar to nasal prongs and a mask, the size of the infant’s head is not determined by the infant’s weight, height or gestational age. Measurements must be completed upon initial set-up and assessed at frequent intervals as the head size changes—as molding from birthing subsides and the baby grows. The fixation devices are single patient use and come in several sizes to ensure the ideal fit.

**Note:** The Infant Flow LP bonnets and headgear are only compatible with the Infant Flow LP nCPAP generator and cannot be used with the original Infant Flow generator.



Bonnet



Headgear

Infant Flow LP bonnets		
Size	Color	Measurement
000	White	18–20 cm
00	Gray	20–22 cm
0	Pink	22–24 cm
1	Light brown	24–26 cm
2	Yellow	26–28 cm
3	Light blue	28–30 cm
4	Gold	30–32 cm
5	Green	32–34 cm
6	Light burgundy	34–36 cm
7	Orange	36–38 cm

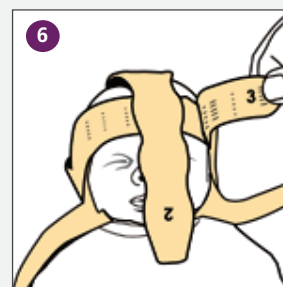
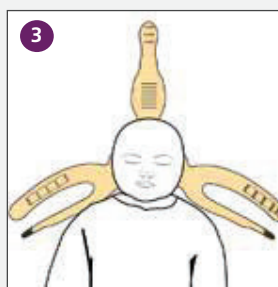
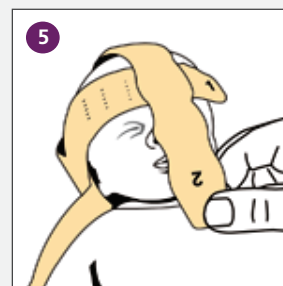
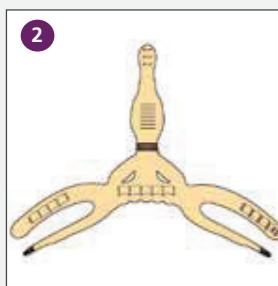
Infant Flow LP headgear	
Head circumference	Size
17–21 cm	Extra small
21–26 cm	Small
24–28 cm	Small/Medium
26–32 cm	Medium
32–37 cm	Large
37–42 cm	Extra large

## Headgear application

Depending on the facility's preference, the clinician may use a headgear or bonnet fixation device. To select the appropriate size headgear, use a measuring tape marked in centimeters to measure the infant's head circumference.

Match the head circumference to the measurement listed on the package and/or back of the headgear.

1. Place the measuring tape above the brow line, and wrap it around the circumference of the head.
2. Lay the headgear on a soft surface with the printed side facing down and the long center strap 2 straight up and away from the patient's head.
3. With the infant face up, gently place the back of the head on the headgear. The straps are numbered to help guide the clinician during application. Using strap 2 for alignment, center the infant's head. Check to ensure the bottom edge of the headgear rests at the nape of the neck.
4. Wrap the side of strap 1 over the patient's forehead, aligning the bottom edge of the strap with the patient's brow. Do not cover the eyes.
5. Bring strap 2 down over the center of strap 1. Strap 2 should come over the top of the infant's head.
6. Place the side strap 3 over strap 1 and strap 2 to create a snug fit. Gently secure the hook-and-loop tab. Strap 3 should lie directly over strap 1 with the bottom edges aligned with the patient's brow.
7. Fold the excess length of strap 2 back over strap 3, and secure it to itself using the hook-and-loop.



## Generator assembly preparation

Following the facility's protocol, set up the Infant Flow SiPAP or nCPAP driver and attach a breathing circuit. The heated, single-limb infant breathing circuit must be compatible with the humidifier. Remove the Infant Flow LP generator from the package, and ensure the corrugated tubing is fully extended. Firmly attach the pressure line of the breathing circuit to the generator assembly pressure line. Next, attach

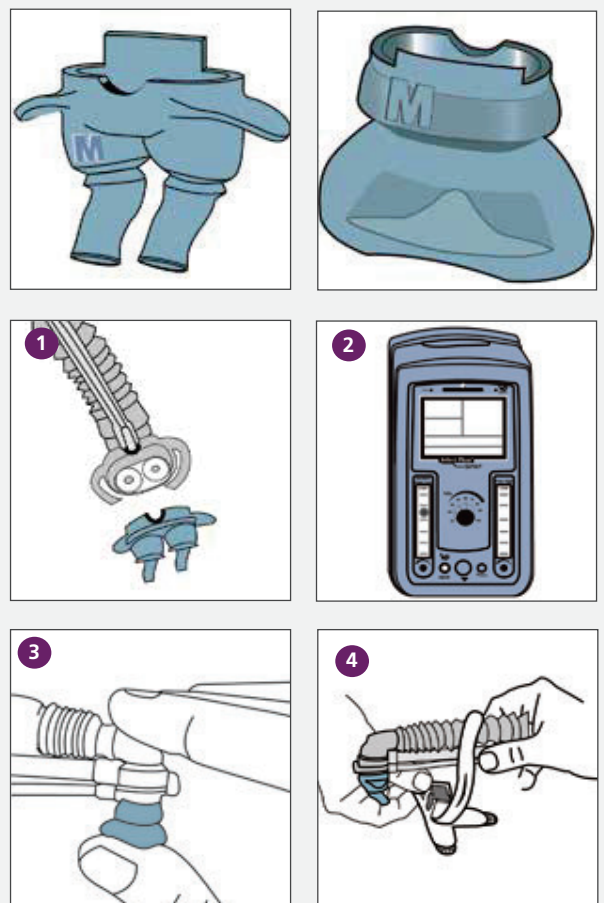
the breathing circuit supply line to the drive line of the generator assembly. Ensure the fittings are tight. Attach the nasal prongs or nasal mask to the generator. A second clinician may be needed to assist during the application process.

Proper sizing is critical for effective therapy. Use the nasal prong and nasal mask sizing guide to select the correct interface size. The nasal prongs and masks are color-coded for quick size identification and match the sizing guide colors. The size of the interface is also located at the base of the nasal prongs and mask. The base is keyed to ensure the proper placement of the interface onto the generator.

1. Align the indentation at the base of the nasal prong or mask over the pressure line. Press it evenly onto the generator, and check it for a tight fit.
2. Set the flow rate to deliver the prescribed pressure.
3. Occlude the prongs or mask, and verify that the CPAP level is reached. If the desired CPAP level is not achieved, check for leaks.
4. Remove the support cradle from the generator assembly.

**Tip:** Routine care: Choosing nCPAP over intubation can provide a gentler therapy option. It also introduces some delivery challenges as the delicate skin of premature infants is extremely susceptible to damage from excessive pressure or abrasion. The infant's nasal area must be routinely inspected for skin irritation and breakdown; if indicated, discontinue therapy. Periodically alternate between the nasal prongs and mask to help reduce the incidents of skin breakdown.

Routinely inspect/visualize the area under the fixation device for skin irritation. Remove and/or adjust the fixation device as needed to ensure proper placement.





## Generator assembly and interface attachment

The generator assembly has a support cradle used to secure the generator assembly to the headgear and help properly align the nasal prongs or mask to the infant's nose. Headgear should fit snugly to prevent slippage.

Do not overtighten. If the headgear is too tight, it may cause head molding and additional pressure points against the infant's delicate skin.

### 1. Attach the support cradle

Remove the support cradle from the generator assembly, and position it in the center of the forehead strap. (1a) Gently press the three tabs down. (1b) Ensure that the support cradle does not overlap the edge of the strap or touch the patient's skin.

### 2. Insert the nasal prongs

Select the appropriate size of prongs, and attach them to the generator. (2a) Grasp the generator assembly with two hands. Use one hand to align the generator with the nasal prongs perpendicular to the nose and the other hand to align the exhaust tube over the support cradle. (2b) For easy application, moisten the prong tips with sterile water. Start one prong at a time, and use a gentle side-to-side motion during insertion. A seal is created with the flared section of the prong, not from inserting the prong to the base. Do not insert the prongs beyond the flexible bellow section.

### 3. Apply the nasal mask

Select the appropriate mask size, and attach it to the generator. Note that the mask size may vary from the nasal prong size. Hold the generator assembly with two hands, and center the mask over the nose. (3) Gently place the mask on the infant's face to retain the mask's original shape. The mask should fit around the perimeter of the nose, without touching the eyes and blocking the nares.

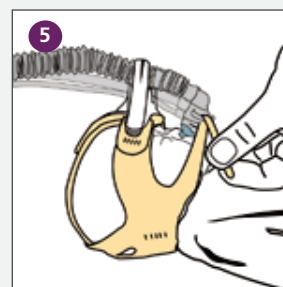
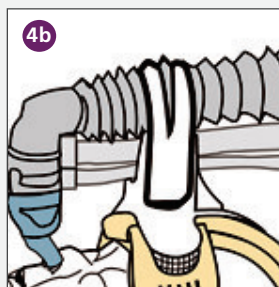
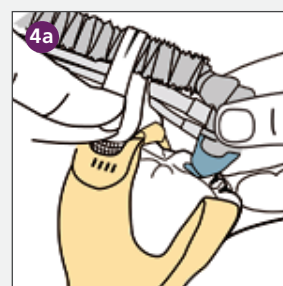
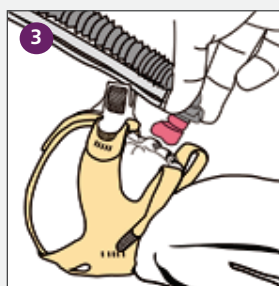
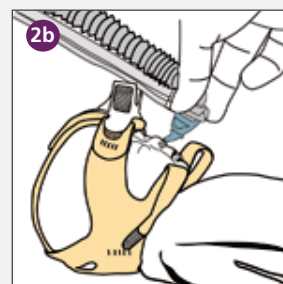
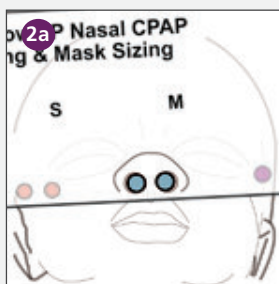
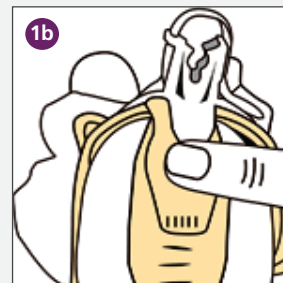
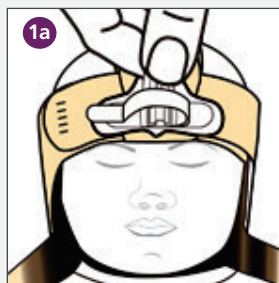
### 4. Secure the generator assembly

After placing the nasal mask or prongs, position the drive and pressure lines in the support cradle with the exhalation tube resting on top of the cradle. Wrap the locking strap over the exhalation tube, and attach it to the side of the support cradle. (4a) To help hold the exhalation tube in place, position the slit in the locking strap over a bend in the corrugated tube—**do not overtighten the straps**. (4b)

### 5. Connect the side straps

Using the lower side strap, fold over the fixation tab and secure it back onto the headgear. Attach the second side

strap to the generator. (5) The straps should lie low on the cheeks and away from the infant's eyes. Check that the straps lie flat on the cheek and are not twisted—**do not overtighten the side straps**.



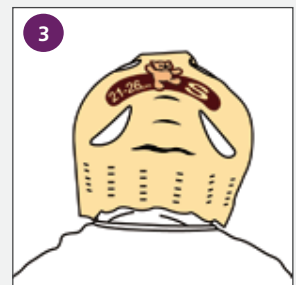
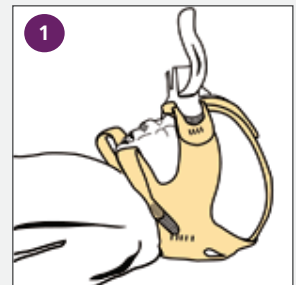
## 6. Inspect the headgear

After applying the headgear, inspect it for proper fit, strap placement and tension. When properly attached, the generator should sit perpendicular to the infant's face. After applying the headgear and generator, conduct a final check for proper placement. The septum should always be visible. If not, the prongs are in too deep or the straps are pulled too tight.

- Align the side straps with the brow line, without them covering the eyes or resting in the center of the forehead. This ensures the proper placement of the support block and correct position of the generator assembly. If the straps are placed too high on the forehead, they affect the alignment of the interface. This may cause the interface to push up against the nasal septum or make it difficult to maintain a good seal with the mask and prongs.
- Evenly cover both ears with the fixation device. This helps protect the ears and muffle the sound created by the variable flow generator.
- Confirm the ears are flat, not folded underneath the headgear. Conduct routine checks behind the ear for skin irritation or moisture buildup.
- Check that the scalloped bottom of the headgear lies at the nape of the neck.
- Confirm the headgear is snug enough to maintain a proper fit and prevent slippage.
- Avoid using headgear that is too large. Otherwise, the headgear folds in the back and does not conform to the shape of the infant's head.
- Ensure the straps lie flat and are not twisted.
- Routinely check the measurement of the head circumference and adjust the headgear as indicated to accommodate the infant's changing head size.

## Correct headgear placement

1. The straps are aligned correctly to the brow line. The center strap is properly folded back, without too much tension on strap 3.
2. The headgear lies flat and fully covers the ear without any large folds in the back of the headgear.
3. The scalloped edge of the headgear lies at the nape of the neck. The back of the headgear conforms to the infant's head.



## Bonnet application

Depending on the facility's preference, the clinician may use either a bonnet or headgear fixation device. To select the appropriate bonnet size, use the colored sizing guide provided.

**Tip:** Bonnet sizing—Do not use a head circumference measurement, as it does not provide an accurate measurement.

### Select the correct bonnet size

1. Start at the center of the forehead, measure to the nape of the neck and measure back to the center of the forehead. The colored squares and numbers on the sizing guide correlate to the bonnet size. For example, match the green square to the green trim on the bonnet, which is size 5. (*chart A*) The cotton fabric on the bonnet stretches a little. If between sizes, select the smaller size.

### Apply the bonnet

2. With help from another clinician, align the tip of the bonnet pad with the center of the forehead and nose. Gently pull the bonnet down over the infant's head until the ears are covered. The button holes should be positioned over the ears.

### Attach the support block

3. Remove the support cradle from the generator assembly, and position it in the center of the forehead strap. Press the three tabs down. Ensure that the support cradle does not overlap the edge of the strap or touch the patient's skin.

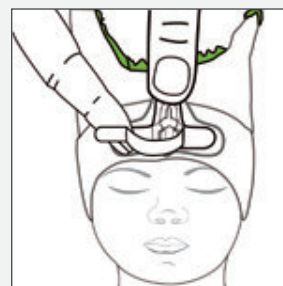
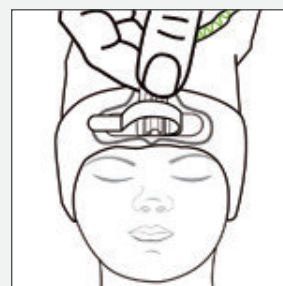
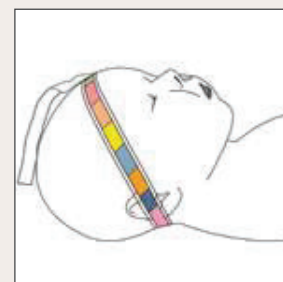


Chart A—Sizing guide



## Generator assembly and interface attachment to bonnet

A special pad on the bonnet holds the support cradle in place. This secures the generator assembly to the bonnet and helps properly align the nasal prongs or mask to the

infant's nose. The bonnet should cover the ears and fit snugly to prevent slippage—**do not overtighten the side straps.**

### Attach the straps to the quick secure tab

1. Pull the slanted end of the gray strap through the slit on the opposite end to form a loop. (1a) Slide the loop over the quick secure tab on the generator, and pull it tight. Repeat the procedure to attach the second gray strap to the fixation tab. (1b)

### Insert the nasal prongs

2. Select the appropriately sized prongs, and attach them to the generator. (2a) Grasp the generator assembly with two hands. Using both hands, align the generator assembly perpendicular to the nose with the exhaust tube above the support cradle. (2b)

For easy application, use a gentle side-to-side motion to insert one prong at a time. A seal is created with the flared tip. Do not insert the prongs beyond the flexible bellow section or to the base of the prong. The septum should be visible. Larger nasal prongs may be indicated to obtain a seal if the straps are pulled too tight or the prongs inserted too deep.

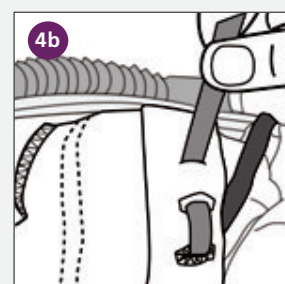
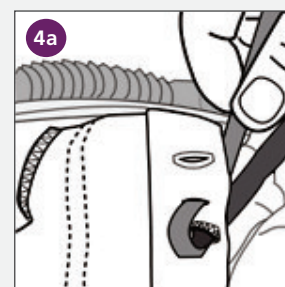
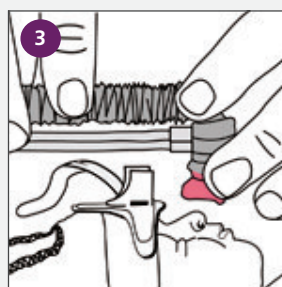
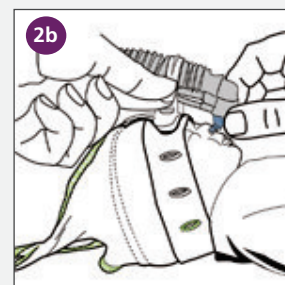
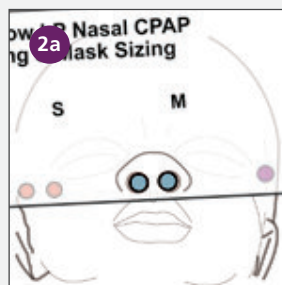
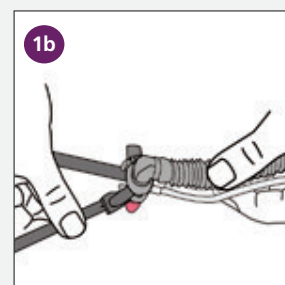
### Apply the nasal mask

3. Select the appropriate mask size, and attach it to the generator. Note the mask size may vary from the nasal prong size. Hold the generator assembly with two hands, and center the mask over the nose. Gently place the mask on the infant's face to retain the mask's original shape. The mask should fit around the perimeter of the nose, without touching the eyes and blocking the nares.

### Attach the generator assembly to the bonnet

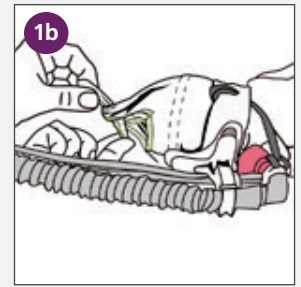
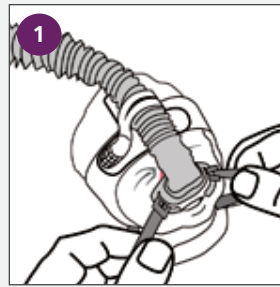
4. To attach the generator assembly to the bonnet, turn the infant's head to one side. Have one clinician hold the infant's head to the side, while the other clinician threads the gray straps to the bonnet. Starting with the colored hole, weave the gray strap through the bonnet holes. (4a) Thread up through the colored hole, down through the second and up through the third. (4b)

Turn the infant's head to the other side and repeat the weaving process with the second grey strap. Adjust the tension on the straps. The gray straps should lie horizontally across the cheeks. Ensure the straps are not resting close to the eyes.



### Adjust the strap tension

1. Adjust the tension of the side straps. If the bellows on the prongs or mask are collapsed, the straps are too tight. The gray side straps should lie low and horizontally across the infant's cheeks. Ensure the straps are not resting against the eyes. Tuck the end of the straps under the bonnet fold, and tie the ends of the bonnet on top of the infant's head.



### Inspect the bonnet

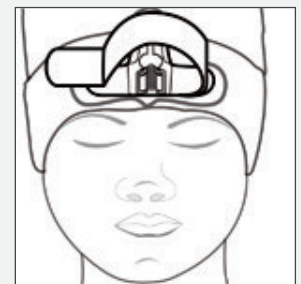
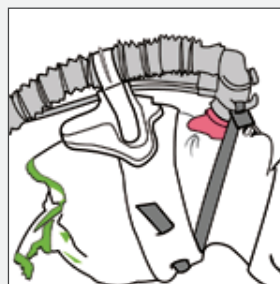
After applying the bonnet, inspect it for proper fit and strap tension.

1. Center the support cradle midline to the forehead and align to the nasal profile.
2. Place the bottom edge of the bonnet at the brow line, without covering the eyes. This ensures the proper placement of the support cradle and correct position of the generator assembly. If the bottom of the bonnet is placed too high on the forehead, it affects the alignment of the interface. This may cause the interface to push up against the nasal septum or make it difficult to maintain a seal with the nasal mask or prongs.
3. Cover both ears evenly with the bonnet. This helps protect the ears and muffle the sound created by the variable flow generator.
4. Ensure the ears are flat against the forehead, not folded. Conduct routine checks behind the ear for skin irritation or moisture buildup.
5. Check that the bonnet is snug enough to maintain a proper fit and prevent slippage. If it is too tight, loosen the threading until the interface bellows and the septum shows.
6. Avoid using a bonnet that is too large. Otherwise, the bonnet material buckles and does not conform to the shape of the infant's head.
7. Confirm the straps lie flat on the infant's cheek and are not twisted.

8. Routinely check the measurement of the head circumference, and adjust the headgear as indicated to accommodate the infant's changing head size.

### Correct bonnet placement

1. The bottom of the bonnet sits at the brow line.
2. The side straps lie flat and low on the infant's cheeks.
3. The generator assembly is properly centered.
4. The bonnet covers the ears. The ears lie flat, not folded.
5. The strap is threaded correctly. The bonnet conforms to the shape of the head.
6. The top of the bonnet is tied off.
7. The support cradle is centered and midline with the nasal area.





## Bonnet application (*alternative method 1*)

The previous section outlined the most common method for applying the bonnet. However, some clinicians may find

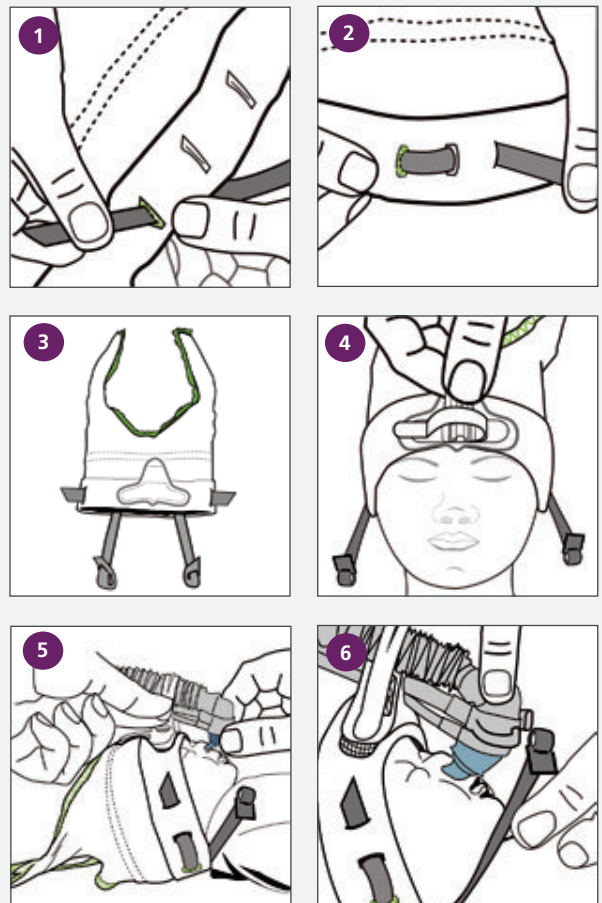
it more convenient or easier to use one of the methods described in the following pages.

### Thread the gray straps to the bonnet

As one alternative method, to apply the bonnet with gray straps pre-threaded:

1. Create a loop on both straps. Take the slanted end of the gray strap and pull through the slit on the opposite end to form a loop.
2. Starting from the under side of the bonnet, thread up through the colored hole, down through the center hole and back up through the last hole.
3. The excess length of the gray strap should be before the colored hole. When laid flat, the longer part of the strap is at the back of the bonnet.
4. Pull the bonnet down over the patient's head and ensure the gray straps are brought forward and resting on the side of the face. Attach the support cradle to the bonnet.
5. Use one hand to align the generator with the interface perpendicular to the nose, and use the other hand to position the exhaust tube over the support cradle. Secure the exhaust tube, drive and pressure lines to the support cradle.
6. While holding the generator assembly in place, take the gray strap and place the loop over the quick secure tab. Pull tight on the loop to adjust the tension of the gray strap.
7. Repeat the process on the other side, and conduct a final inspection.

**Note:** During the bonnet application, ensure the straps are pulled forward and are not caught underneath the back of the bonnet. If the loop pulls out, pull it open before attaching it to the quick secure tab. Another clinician should assist with the application.





## Bonnet application (*alternative method 2*)

A second method for applying the bonnet is attaching the generator assembly to the bonnet prior to application. All three methods discussed are acceptable ways to apply the

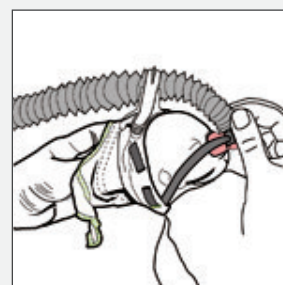
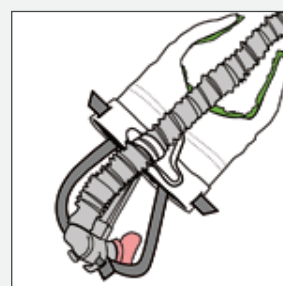
bonnet and generator assembly. Clinicians should use the method that they are most comfortable with and best fits the situation.

### Attach the generator assembly to the bonnet

Another option for applying the bonnet is to attach the generator assembly, interface and support cradle prior to application.

1. Prepare the generator assembly as indicated in the previous section. Attach the desired interface and connect the gray straps to the quick secure tabs.
2. Center the support cradle on the application pad.
3. Place the drive and pressure lines in the support cradle with the exhaust tube resting on top. Wrap the securing strap around the exhaust tube, and attach it to the hook material on the side of the support cradle. Keep a little slack in the securing strap to freely move the generator when ready to position it.
4. Thread the side straps onto the bonnet to fasten the generator assembly to the bonnet.
5. Pull the bonnet and generator assembly down over the infant's head. Make any necessary adjustments to properly position the generator and interface over the infant's nasal area.
6. Insert the nasal prongs or position the mask. Adjust the tension of the side straps.
7. Complete a final inspection of the set-up. Confirm the infant's ears are covered and the bonnet's edge is at the brow line. Check that the interface is properly positioned and a good seal is achieved.

**Note:** The preparation of the bonnet and generator assembly can be completed prior to application. The actual process of applying it to the infant may be a little cumbersome. It takes practice to keep the generator assembly from brushing against the infant's face while pulling the bonnet down over the head. Ask another caregiver to assist during the application process.



## Incorrect application of fixation device and generator assembly

Properly sizing and placing the fixation device, headgear or bonnets is essential for the proper alignment and stability of the generator assembly. Too small and too tight of a fixation device may cause head molding or skin irritation.

If the fixation device is too large, slippage can occur, creating additional torque on the generator assembly or dislodging the interface.

### Incorrect headgear position

1. Headgear straps 1 and 3 are too high on the forehead, and the center strap is pulled too tight.
2. The center strap 2 is not midline to the nasal profile.

Corrective action: Reposition the headgear with forehead straps 1 and 3 positioned at the brow line, and center strap 2 over the crown and midline with the nose.

### Incorrect headgear size

3. The headgear is too small, not covering the ears and sitting too high on the back of the head.
4. The headgear is too large, causing folds or gaps in the back of the headgear. The side straps are too long.

Corrective action: Recheck the head circumference measurement and resize it as indicated.

### Incorrect exhaust tube position

5. The support strap is not wrapped over the exhaust tube.
6. The exhaust tubing pulls forward.

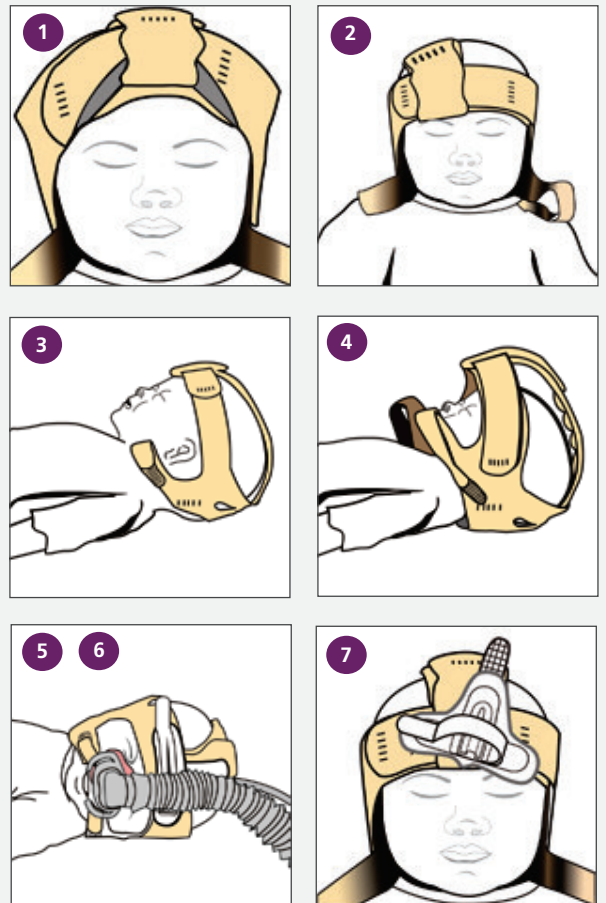
Corrective action: Unhook the support strap and position the exhaust tube on top of the support cradle. Wrap the support strap over the exhaust tube, and secure it to the side of the support cradle. Ensure the slit in the support strap fits over the corrugate.

Reposition the exhaust tube and circuit to follow the curvature of the head.

### Incorrect support cradle application

7. The support cradle overlaps the edge of the forehead strap and does not align with midline to the nasal profile.

Corrective action: Remove the support cradle and reposition it in the middle of the forehead and center straps.



#### Incorrect bonnet position

1. The bonnet is seated too high on the forehead.
2. The support attachment pad is not midline to the nasal profile.

Corrective action: Reposition the bonnet. The side of the bonnet should cover the infant's ears, and the front of the bonnet should sit at the brow line.

#### Incorrect exhaust tube position

3. The support strap is not wrapped over the exhaust tube.
4. The exhaust tubing pulls forward, away from the infant.

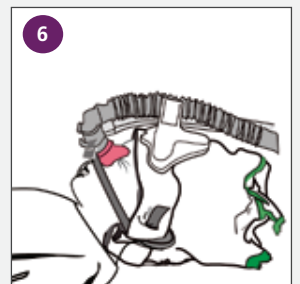
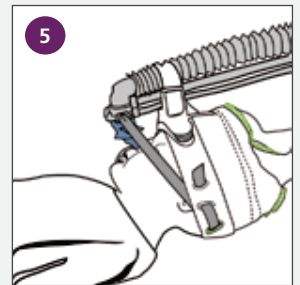
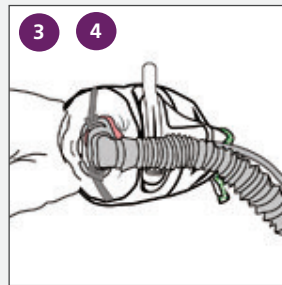
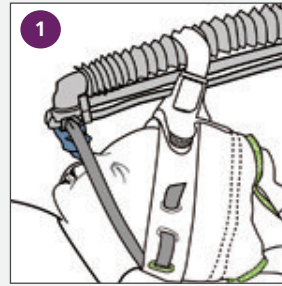
Corrective action: Reposition the support strap. The exhaust tube should sit on top of the support cradle with the securing strap around it. Ensure the slit in the securing strap is over the corrugate.

Remove the support cradle, and reposition it in the middle of the forehead and center straps.

#### Incorrect bonnet size

5. The bonnet is too small, not covering the infant's ears and sitting too high on the forehead. The side strap lies too close to the eyes.
6. The headgear is too large. Excessive material is causing folds to occur.

Corrective action: Recheck the head measurements. Measure from the center of the forehead to the nape of the neck, and back to the center of the forehead. Select the appropriate bonnet size.



## Incorrect application of generator assembly and interface

Properly sizing and placing the patient interface are essential for optimal therapy delivery. Incorrectly applying the interface may lead to air leaks, pressure points, nasal injury and therapy interruption.

Conduct routine checks according to the facility's protocols to ensure the proper placement of the interface.

### Incorrect nasal prong position

1. One prong is not in the nostril.

Corrective action: Remove the prongs and reinsert the prong tips into each nostril.

2. The base of the prongs is not sitting properly on the generator receiver.

Corrective action: Remove the interface and reapply it while ensuring the interface is evenly seated.

### Side straps are too tight

3. The prongs are in the nostrils too far, compressing the bellows.

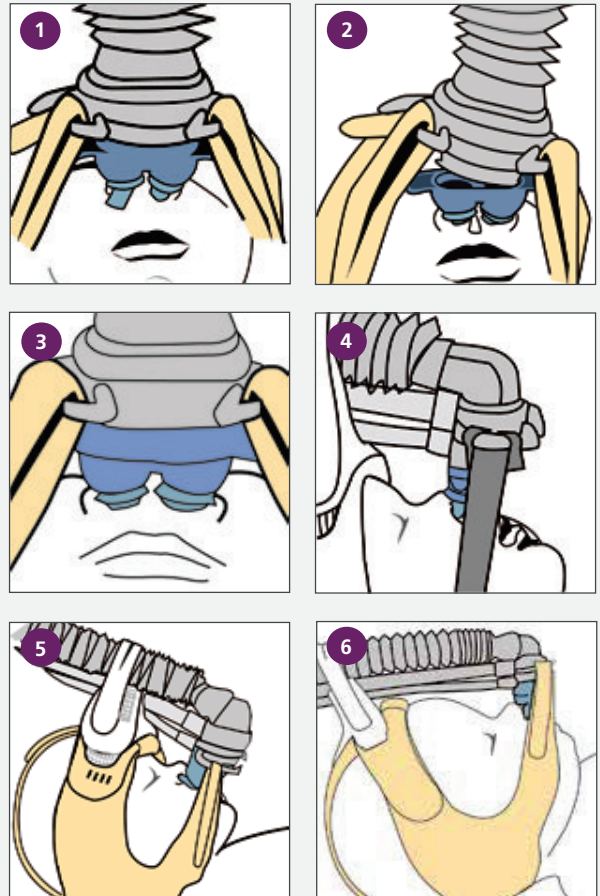
4. The base of the interface is resting on the apex, and the prongs are pressing against the nasal septum.

Corrective action: Release the tension on the straps until the tops of the bellows are visible. Only the upper portion of the prongs should be in the nares. Ensure the generator assembly is properly positioned over the nares.

### Improper generator alignment with the infant's nose

5. The nasal prong and generator placement are too far forward, causing the prongs to collapse.
6. The headgear is positioned too far back on the forehead, causing the prongs to kink.

Corrective action: If the generator assembly is positioned in front of the nose, the prongs bend. Loosen the securing strap on the support block and reposition the generator assembly and nasal prongs over the infant's nares. If the generator assembly is positioned incorrectly, it affects the angle of the prongs and causes them to bend or collapse. Ensure the headgear is properly placed above the brow line. Loosen the support strap and slide the generator assembly forward until the generator head is perpendicular to the apex of the infant's nose.



### Improper mask size

1. The mask is too large if the top of the mask rests on the glabella, the area between the eyebrows.
2. The mask is too large if the bottom of the mask covers the infant's lips.
3. The mask is too small if the mask does not cover the perimeter of the nose and the bottom of the mask occludes nares.

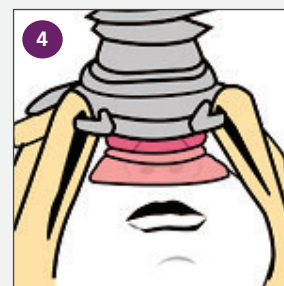
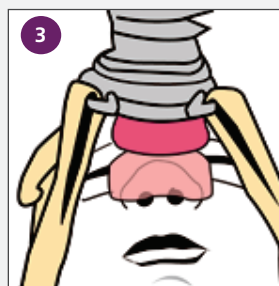
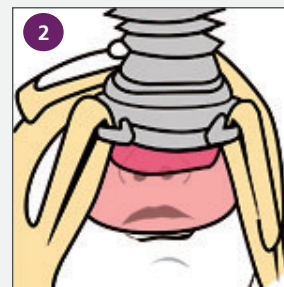
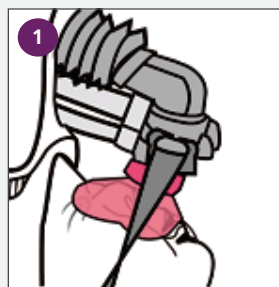
Corrective action: Use the sizing guide to select the proper mask size.

### Incorrect side strap tension

4. The straps are too tight if the bellow is compressed, and the cushion has collapsed.
5. The strap tension is uneven if the bellow is compressed on one side.

Corrective action: Loosen the side straps on the fixation device. Lift the mask up, and reposition it on the infant's face. Readjust the strap tension to ensure the bellow and cushion are not collapsed. The infant's nares should be clearly visible in the assessment window.

**Tip:** The interface must be the correct size, and the fixation device must be properly applied to ensure the generator assembly is properly aligned and stable.



## Final inspection of nasal interface placement

After applying the fixation device and generator assembly, conduct a final check for the proper placement of the nasal prongs and mask. A properly sized and placed interface

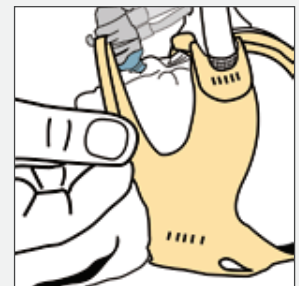
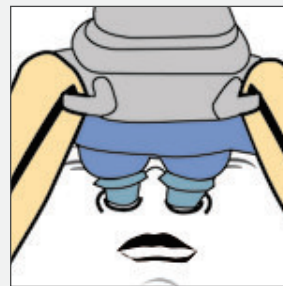
is key to the success of nCPAP therapy. Confirm that the prescribed pressure is being delivered.

### Nasal prong placement

For proper nasal prongs placement, check the following:

- The bellows are visible, not compressed. If the bellows are compressed, use the side straps on the fixation device to adjust the tension applied to the nasal prongs. Loosen the straps until the infant's nasal septum is visible and the bellows pop up.
- The generator and prongs are not touching the upper lip or the apex of the nose.
- The prongs are not kinked or folded over.
- The upper portions of the prongs are in both nares.
- The prongs create a good seal with minimal or no leaks.
- No blanching is on the outer side of the nares. This indicates the prongs are too large.

- The generator and interface are perpendicular to the infant's nose and not leaning to one side.
- The base of the interface is placed evenly on the generator receiver.

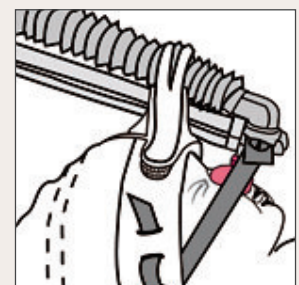
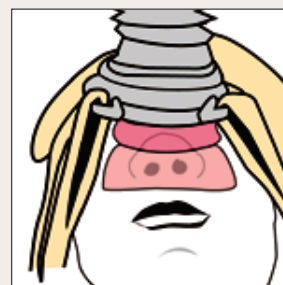


### Nasal mask placement

For proper nasal mask placement, check that:

- The generator and mask are centered over the nasal area.
- The mask covers the perimeter of the infant's nose.
- The mask sits midline between the nose and upper lip. Make sure the mask is not resting on the lip or blocking the nares.
- The bellow is visible, not compressed.
- The infant's nares and septum are visible in the assessment window.
- The mask is fully inflated, not collapsed. If collapsed, the tension on the side straps may be too tight. Loosen the straps until the below and assessment window are visible.

- The mask is seated below the infant's eyes and rests on the bridge of the nose.
- The top of the mask is not resting on the glabella, the area between the eyebrows.
- A good seal is formed with minimal or no leaks. The prescribed pressure is being met.
- The side straps are not too tight.





## Self assessment and return demonstration



Using the training doll provided, follow the steps outlined and document the measurements.

1. Measure the doll's head and select the appropriate headgear size.
2. Measure the doll's head and select the appropriate bonnet size.
3. Use the sizing guide to select the correct interface size.  
Nasal prongs: \_\_\_\_\_  
Nasal mask: \_\_\_\_\_

4. Apply the fixation device (*bonnet or headgear*).

5. Attach the generator assembly with the interface to the fixation device.
6. Inspect for proper application on the doll and obtain feedback from the instructor or another participant.

### Observation skills assessment

This Infant Flow LP system has not been applied correctly. Identify at least four application errors: \_\_\_\_\_

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## Observation skills assessment

This Infant Flow LP system has not been applied correctly.

Identify five application errors: \_\_\_\_\_

[illegible]

Are there any additional application errors? \_\_\_\_\_

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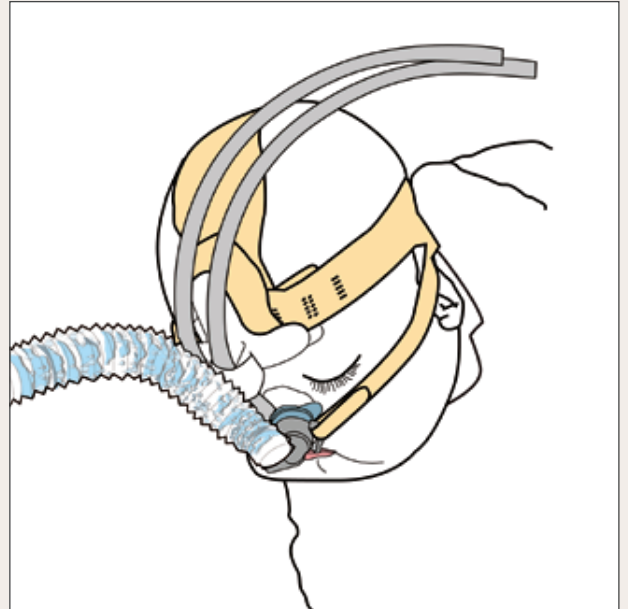
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**Notes:**

[illegible][illegible]

# Routine nCPAP care



## Final inspection and routine care

From the initial application of nCPAP therapy throughout its progress, inspect the system after set-up and routinely, every three to four hours to ensure therapy effectiveness and infant comfort. These checks can be carried out with other routine assessments to minimize stimulation in

the infant. The type and frequency of monitoring and assessment carried out varies depending on each facility's policies and procedures and individual patient needs. This section is only intended as suggested guidelines.

### Hourly

- Verify the infant is receiving prescribed therapy, and check for leaks.
- Check that the generator assembly is stable, secure and not pulling upward on the nose. Should the fixation device or generator appear to be out of alignment once applied, disassemble the fixation device and start over.
- Inspect the fixation device and straps for proper placement and tension. Adjust them as needed to maintain a proper fit, using the least amount of tension possible to maintain stability. During inspection:
  - Confirm the infant's ears are not folded and normally positioned.
  - Ensure the straps are not twisted.
  - Check the humidifier chamber water level.

### Assessment times (*at least every three to four hours*)

- Inspect the skin integrity around the nasal area for deformities or irritation. Gently massaging the contact area may help stimulate circulation.
- Document any changes in the condition of the infant's nose.
- Consider alternating the use of prong and mask interfaces with each infant to avoid breaking down the nasal area.

- Ensure the proper prong size. With prongs, the infant's septum should be clearly visible without compressed bellows. With a mask, the infant's eyes are visible and nares are not blocked.
- Inspect for nasal mucosal damage due to a lack of humidification.
- Monitor for gastric insufflation and abdominal distention.

### Daily

- Document and continue assessing the nasal interface. Include the size of the interface and any changes.
- Check the head measurement, and document the fixation device size.

### Routine respiratory monitoring

- CPAP administered
- Cycle rate
- T-high setting
- MAP
- Delivered FiO<sub>2</sub>

### Infant assessment and monitoring

- Skin color
- Chest wall stability (e.g., retractions)
- Infant's behavior (e.g., irritability)
- Skin condition around the prong or mask interface
- Respiratory rate
- Oxygen saturation
- Heart rate and rhythm
- Blood gas values
- Chest x-rays
- Perfusion-BP, peripheral pulses
- Abdominal girth—may need to insert an orogastric tube

By utilizing this information, members of the multidisciplinary team can provide an individualized plan of care.

### Humidification

A heated humidifier is recommended to warm and humidify the delivered gases to prevent the mucosal lining from drying. Routinely check the generator assembly and interface, and clear them of any mucous or water droplets. If excessive condensation is present, check the water level in the chamber, remove the unheated section of the circuit or lower the humidifier temperature setting.

### Nasal care<sup>3,5,17</sup>

Prevention is the key to reducing nasal septum damage. Preterm infants have very thin, fragile skin due to the immature development of the stratum corneum, which makes the skin particularly vulnerable to damage. If subjected to continuous pressure, friction and/or moisture, the skin will begin to break down. Skin erosion can occur within a matter of a few hours. Diligence in monitoring the nasal area from the bridge to the septum is essential. Avoiding contributing factors help to maintain an intact septum:

- Use the correct nasal prong size. Prongs that are too large cause nare blanching. If the prongs are too small, they may go too far up the nose and press up against the septum.
- Ensure the side strap tension is not too tight.
- Frequently inspect the skin integrity. If noting signs of erosion or grazing, remove the pressure, friction or moisture. Consider alternating the prongs and mask to change the point of pressure.
- Do not use creams, oil or gels.
- Do not cover an injured septum with hydrocolloid shields. The increased moisture may further break down the area.
- Use hydrocolloids and other skin shields with caution. The skin and shields can trap moisture, or the shield can slip and block the nasal passage.

### Positioning<sup>3,5,6</sup>

An infant on CPAP can be positioned in any position—the prone, lateral or supine—as long as it promotes comfort and optimal airway posturing. Repositioning is essential to the infant's neurodevelopmental and respiratory outcomes. If the flexion of the infant's head and neck is too pronounced, the airway may be compromised, but this can be resolved by gentle extension. Positioning aids may be beneficial. Routine positioning allows thorough assessments by the clinicians. The infant should be repositioned as per facility standards.



## Suctioning

Kangaroo care<sup>3-6</sup>Feeding<sup>3-5</sup>

nCPAP is not a contraindication to feeding. Infants receiving nCPAP can be breast, bottle or tube fed, depending on their overall status. The clinician must assess each infant accordingly when introducing a feeding regime. Mild gastric inflation is associated with nCPAP therapy. An orogastric tube may be used to aspirate air prior to feeding. Nasogastric feeding is not recommended as it impedes the fixation of the nCPAP interface and significantly adds to the WOB.<sup>17</sup>

[illegible]

# Frequently asked questions



## Infant Flow LP generator assembly and interface

### Q. What does LP stand for?

**A.** Low pressure. The special patent design of the dual jets requires a lower driving pressure than other variable flow generators.

### Q. Can I use my bonnets from the original Infant Flow nCPAP system with the new Infant Flow LP system?

**A.** No. The Infant Flow LP bonnets have a special pad that attaches to the support cradle. The support cradle lifts the generator assembly up and positions it at the correct angle over the nose. It also provides stability for the generator. The original Infant Flow bonnets do not provide the extra height needed to properly position the generator assembly.

### Q. Are the prongs and mask from the original Infant Flow and AirLife nCPAP systems compatible with the Infant Flow LP generator?

**A.** No. The Infant Flow LP generator is keyed specifically for the Infant Flow LP nasal prongs and masks.

### Q. Can the generator assembly and fixation devices be used on more than one patient?

**A.** No. The Infant Flow LP system is for single patient use only.

### Q. How can I decrease the noise generated by the system?

- Use an Infant Flow silencer connected to the expiratory limb of the circuit to dampen the noise.
- Take care when using the silencer, as it may add resistance to the system. If the filter becomes wet, it increases resistance and WOB. Inspect the silencer frequently, and replace it if wet. The resistance caused by the filters varies according to the size and type of filter material. Only use the silencer/filter approved by CareFusion.

- Attach an extra length of corrugated tubing to the end of the exhalation tube to direct gas flow away from the infant and clinicians. These extension tubes can be ordered separately.

### Q. The masks keep collapsing. What should I do?

**A.** Check the position and placement of the generator assembly. The generator head should be perpendicular to the apex of the nose. If the position is too far back or forward, it changes how pressure is applied to the bellows and causes the mask to collapse. Check the tension on the fixation side straps. If they are too tight, they collapse the bellows and the mask.

### Q. What can I do to prevent the headgear fixation from slipping?

**A.** Measure the circumference of the head to ensure the correct headgear size is used. Readjust the straps until the headgear fits snugly with the forehead straps resting at the brow line and the scalloped edge at the nape of the neck. If the headgear is stretched out of shape, replace with new headgear.

### Q. How can I keep the prongs in place?

**A.** Ensure the correct prong size is used. Check the alignment of the support cradle and generator assembly. The generator assembly should be perpendicular to the nasal profile. Ensure the headgear or bonnet is properly sized and snug to prevent the headgear from moving.



## Infant Flow LP generator assembly and interface (*continued*)

### Q. How do I prevent nasal septal injury?

- Use the correct nasal prong and mask size. Prongs that are too large may cause excessive pressure against the nares and septum. Prongs that are too small may increase movement and friction.
- Avoid overtightening the fixation side straps.
- Properly align the support cradle and generator assembly to the nasal area.
- Frequently inspect the nasal area for skin irritations, and remove any moisture.
- Keep the generator assembly positioned to minimally contact the nasal interface to the infant's skin.
- Alternate between the nasal prongs and mask interface.
- Use positioning aids to help keep the infant in position if the bed is tilted. Otherwise, the infant may migrate down, causing the circuit to pull against the nasal septum.
- Do not use creams, gels, lubricants or hydrocolloid products, as they may lead to excessive moisture and undermine the skin integrity.
- Refer to the Routine Inspection section, nasal care, for a more detailed description.

### Q. What causes nasal blanching?

- A.** Two main causes are the prongs are too large or incorrectly positioned. Recheck the measurement. If the selected prong is the best size, try dilating the nares before inserting the prongs. Insert only one prong into the nare, and allow it to dilate. Remove the prong and repeat the insertion with the other nare. Then, try inserting both prongs.

### Q. Can I prevent the “pig nose” appearance, often associated with nCPAP?

- A.** The “pig nose” is caused by the nasal interface and generator pushing up against the nasal septum for an extended period of time. This occurs when the generator assembly is not properly aligned with the infant's nose. If the generator assembly sits too far back in the support cradle, it applies pressure against the nose. If the headgear or bonnet are too high on the forehead and not at the browline, it causes the generator assembly to pull back and the nasal interfaces to push up against the septal area.

### Q. How do we clean the circuits, prongs, masks, headgear and bonnets between patients?

- A.** All of these devices are for single patient use only and should not be reused.

## nCPAP therapy

### Q. The infant has thickened oral and nasal sections. Do I need to carry out routine suctioning?

- A.** When receiving nCPAP therapy, routinely suctioning the infant's oropharynx and nasopharynx is not required. Suctioning should only be carried out with clinical need. Over vigorous suctioning can cause further secretion production in response to the procedure. If the infant exhibits signs of increased WOB or distress, suctioning may be indicated.

### Q. Can you nebulize medication through the Infant Flow LP generator?

- A.** No. The system is not designed for the nebulization of medications. If the nebulizer was placed in line prior to the impinging jets, the majority of the medication would be pushed out the exhalation tube. The additional flow used for the nebulizer would impact the pressure delivery.

## nCPAP therapy (*continued*)

### Q. Is humidification required with nCPAP?

A. Humidifying and warming inspired gases are essential in nCPAP therapy. The high gas flow may dry the mucosa, decrease mucociliary action and increase airway resistance.

### Q. Do infants receiving nCPAP therapy suffer from stomach distension?

A. Gastric distension is caused by the infant swallowing air. If mild distension occurs, an orogastric tube can be used to aspirate the air from the stomach. Aspirate excess air prior to feedings. Follow the facility standard of care. Avoid using nasogastric tubes, as they interfere with the seal with a nasal mask. With nasal prongs, the clinician has to select a smaller prong size, which can create leaks. Nasogastric tubes are also associated with higher WOB for the infant.

### Q. Can I use hydrocolloid tape or similar materials around the nasal area?

A. Take care when using hydrocolloid tape to ensure that moisture does not collect under the tape, and change the tape frequently. Moisture under the hydrocolloid

tape may cause it to slip, blocking the nares, dislodging the prongs or causing the prongs to kink. The moisture under the tape may increase the risk for skin breakdown. If the proper prong size is used and the generator is positioned properly, hydrocolloid tape should not be necessary.

### Q. Can a pacifier be used with an infant on nCPAP?

A. Yes. A pacifier does not interfere with nCPAP therapy. If the infant's mouth is open, it may decrease the delivered pressure. The pacifier helps keep the infant's mouth closed.

### Q. Can nCPAP be used on infants with a cleft palate?

A. Upper airway abnormalities, such as cleft palate, choanal atresia and a tracheoesophageal fistula, are considered contraindicated for nCPAP therapy.

### Q. Can the infant receive phototherapy while on nCPAP?

A. Yes, phototherapy is not a contraindication to nCPAP therapy. Place eye patches over the eyes before starting therapy, and avoid obstructing the view of the nasal interface and septum.

## Infant Flow SiPAP nCPAP driver

### Q. When should I calibrate the oxygen sensor?

A. The oxygen sensor drifts with extended use. At a minimum, calibrate the oxygen sensor with the initial set-up and circuit changes.

### Q. The displayed O<sub>2</sub>% does not correlate to the setting the oxygen control dial. What is the correct value?

A. The markings on the oxygen control dial (*blender*) are for reference only. For an accurate reading, refer to the O<sub>2</sub>% displayed on the screen. If a significant difference exists between the two, recalibrate the oxygen sensor.

### Q. I have disabled the oxygen sensor. Do I need to use an external oxygen analyzer?

A. Whenever the oxygen sensor has been disabled, you must use an external oxygen analyzer to monitor the delivered oxygen.

### Q. What causes the blender alarm to sound?

A. The air and oxygen hoses are not connected correctly to the gas sources. The blender alarm has been triggered from the difference in pressures  $\geq 2$  bar (29 psi).

## Infant Flow SiPAP nCPAP driver (*continued*)

**Q.** What triggers the SiPAP nCPAP driver to alarm?

- A.** Refer to the operator manual for the list of alarm triggers. Some of the more common alarms are:
- The alarms were not reset after a change in CPAP level or oxygen setting. To fix, hold the alarm reset bar down for three seconds to reset the alarm thresholds.
  - Check the system for leaks. The nasal interface may be improperly positioned or the infant's mouth may be open.

**Q.** Why does the SiPAP not deliver a pressure boost when the manual breath button is pressed?

- A.** When the system is in the CPAP mode, the high flowmeter needs to be set for the manual breath to be active.

**Q.** Why is the system not reaching the high pressure setting? The SiPAP system is set at 10 cmH<sub>2</sub>O/5 cmH<sub>2</sub>O, T-high 0.3 sec, Rate 20, 30%. Even when the flow rate on the high pressure flowmeter was increased, the maximum high CPAP reached was 9 cmH<sub>2</sub>O.

- A.** The SiPAP system has a slow ramp to the high pressure setting. If the inspiratory time is not long enough, the high pressure is not reached. First, check the breathing circuit and generator assembly for leaks. If the problem does not correct, increase the T-high setting, monitor for an increase in the high pressure and increase the T-high until the desired pressure is reached.

**Q.** Can the SiPAP nCPAP driver deliver nitric oxide?

- A.** The FDA has approved the use of the INOMAX DS with the SiPAP driver for delivering nitric oxide. Refer to the Ikaria INOMax operator manual for the directions of use.

**Q.** When the system is connected to the infant, a flow rate of 9 LPM does not deliver 5 cmH<sub>2</sub>O. Why is this?

- A leak is in the breathing circuit and generator assembly.
- The prongs and mask interfaces are not the proper size.
- The strap tension is too tight, which can break the seal on the interface.
- Leaks in the circuit could be caused by loose connections, pinholes or temperature probes not fully inserted in the temperature port.

**Q.** Air is backing up into the humidifier's water auto-feed system. What should I do?

- A.** Ensure the height of the water bag is at least 50 cm above the humidifier chamber. If air still accumulates, apply a pressure cuff around the water bag.

## Self assessment



1. Why is selecting the proper prongs/mask size important?

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2. When properly positioned, the generator should sit \_\_\_\_\_ to the infant's face.

3. List at least three assessments that should be conducted every three to four hours while on nCPAP therapy:

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4. List three ways to help prevent nasal injury: \_\_\_\_\_

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5. The Infant Flow LP components are interchangeable with the original Infant Flow nCPAP system.

True \_\_\_\_\_ False \_\_\_\_\_

6. List three actions that help prevent nasal injury:

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7. Explain why the SiPAP system does not deliver a breath while the manual breath button is pressed: \_\_\_\_\_

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8. Medications can be nebulized through the Infant Flow LP generator.

True \_\_\_\_\_ False \_\_\_\_\_

9. A flow rate of 9 LPM will deliver how much CPAP?

\_\_\_\_\_ 3 cmH<sub>2</sub>O

\_\_\_\_\_ 5 cmH<sub>2</sub>O

\_\_\_\_\_ 7 cmH<sub>2</sub>O

\_\_\_\_\_ 9 cmH<sub>2</sub>O

**Notes:**

[illegible]

## Glossary



**Abdominal respiratory sensor:** A pressure sensor taped to the infant's abdomen to sense respiratory efforts. The signal returns back to the SiPAP driver through a transducer interface.

**Added work of breathing (WOB):** The extra effort or work that is created by the introduction of an artificial system used to supply enriched gas to support the infant.

**Apnea of prematurity:** Cessation of breathing in a premature infant for 15 seconds and associated with hypoxia or bradycardia.

**Bubble CPAP (B-CPAP):** A constant flow of heated and humidified gas, where the level of pressure is controlled by the depth of the exhalation tube in a water container.

**BiPhasic:** Bi-level noninvasive ventilation mode, which cycles between high and low CPAP levels on a timed basis. For use with a spontaneously breathing infant.

**Bradycardia:** When the heart rate in a newborn falls below 100 beats per minute.

**Breathe:** The inspiratory phase as expiration is passive.

**CPAP:** The application of positive pressure to the airways of a spontaneously breathing infant throughout the respiratory cycle.

**Conventional CPAP (V-CPAP):** Noninvasive ventilation utilizing a traditional mechanical ventilator to deliver CPAP.

**Extubation:** ET tube removal.

**Fixation device:** The device used to secure the generator to the infant, referring to either the bonnet or headgear.

**Fluidic flip:** The key to the functionality of the Infant Flow LP Generator. This occurs within the generator in harmony with the infant's breathing pattern. The patented internal design of the generator manipulates the gas flow to provide a stable CPAP level at the

infant's airway. Because the device depends on fluidic action and not valves or other mechanical devices, the response time to the infant's respiratory effort is almost instantaneous. During expiration, gases are flipped away from the infant, and during inspiration, the flow flips back.

**Generator assembly:** The generator, exhaust tube, proximal pressure line, drive pressure line, support block and interface.

**High flow nasal cannula (HFNC):** A constant flow of heated, humidified gas that potentially delivers positive distending pressure via a nasal cannula.

**Infant Flow SiPAP Plus driver:** A dedicated flow driver for use with infant nCPAP variable flow generators. The SiPAP Plus driver provides two modalities of respiratory support: nCPAP and BiPhasic. Infant monitoring, alarms and safety features are built into the driver to ensure the system operates correctly and the infant's respiratory efforts are supported safely.

**Infant Flow LP SiPAP Comprehensive driver:** A dedicated flow driver for use with infant nCPAP variable flow generators. The comprehensive model provides three modalities of respiratory support: nCPAP, BiPhasic and BiPhasic trigger. The trigger mode utilizes the respiratory abdominal sensors to synchronize supported breaths. Infant monitoring, alarms and safety features are built into the driver. Not available in the U.S.

**Infant Flow LP nCPAP generator:** A single infant use, dual-jet generator that delivers the CPAP therapy. The patented Infant Flow LP Generator is designed to reduce the added work of breathing by providing active assistance to the infant on inspiratory and expiratory phases of the respiratory cycle. The infant interface is provided by the use of nasal prongs and nasal masks.

**Infant Flow transducer:** The connection from the SiPAP driver to the respiratory abdominal sensors for respiratory rate monitoring and synchronization.

**Interface:** Either a nasal mask or nasal prong connected to the generator used to deliver nCPAP.

**Low birth-weight infant:** An infant born weighing less than 2,500 grams.

**Nasal CPAP (nCPAP):** A continuous flow of gas administered through nasal prongs inserted in the infant's nares or a nasal mask placed around the perimeter of the nose.

**Nasogastric tube (NGT):** A soft, flexible tube that is passed through the nose and oropharynx, down into the esophagus, where it enters the stomach. Nutrition and oral medications can be administered through the nasogastric tube.

**Neonate:** A newborn infant from birth to four weeks.

**Orogastric tube (OGT):** A soft, flexible tube that is passed through the mouth and oropharynx, down into the esophagus, where it enters the stomach. Nutrition and oral medications can be administered through the orogastric tube.

**Premature/Preemie:** An infant born before 37 weeks of gestation.

**Respiratory acidosis:** A decrease in arterial Ph below 7.35 from the norm and usually associated with retention of arterial CO<sub>2</sub>.

**Respiratory distress syndrome (RDS):** A common respiratory disorder in premature infants caused by the deficiency of surfactant defined by respiratory difficulty. RDS is characterized by rapid respirations, nasal flaring, intercostal retractions, expiratory grunting, and diffuse haziness and infiltrates noted on chest x-rays. Treatment requires either supplemental oxygen or respiratory support.

**Surfactant:** A phospholipid, which reduces the surface tension, allowing the lungs to become more compliant.

**Support cradle:** The support cradle stabilizes the generator assembly and helps maintain proper alignment with the nasal area.

**Time high (T-high):** In bi-level or BiPhasic ventilation, the set duration for the high CPAP setting.

**Variable flow CPAP (VF-CPAP):** The creation of a CPAP level based on flow utilizing fluidic principles. Rather than provide a constant flow of gas, VF-CPAP provides a direction of gas flow that depends on the infant's respiratory cycle. When the infant exhales, the flow flips away from the nares and then, flips back as the infant begins to inhale.

**Very low birth-weight:** An infant weighing less than 1,500 grams at birth.

**Work of breathing (WOB):** The amount of effort breath.





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 **Caution**—U.S. Federal Law restricts this device to sale by or on the order of a physician.

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