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Noninvasive Positive Airway Pressure in the Perioperative Setting

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On behalf of the SASM Clinical Committee

http://www.sasmhq.org
Noninvasive Positive Airway Pressure in the Perioperative Setting

• Indications and contraindications for Noninvasive PAP therapy

• Primary Noninvasive PAP modes available
  – Matching the mode to the condition

• Implementing therapy
  – Masks, PAP settings

• Monitoring therapy

• Adjunctive treatments
Noninvasive PAP Therapies

Decision to be Made

• Is PAP therapy required?
  – Airway obstructing?
  – Witnessed central apneas?
  – Uncontrolled hypoventilation and/or hypoxemia?

• If so, what type of PAP therapy is warranted?
  • CPAP, BPAP, ASV
  • Indications for each modality, consider contraindications, consider timing of the intervention

• Should it be delivered invasively or non-invasively?
  – Invasively = intubation and ventilator support
  – If non-invasively, via face mask or nasal mask?
Noninvasive PAP Therapies

Decisions to be Made

• What settings? At start ... and subsequent adjustment?
  • Therapy: mode, inspiratory and expiratory pressures, back up rate, Ti
  • Comfort: expiratory pressure relief/flex control, rise time, ramp
  • Alarms: apnea, disconnect, low minute ventilation, low ventilation, power failure (with uninterruptable power supply)
  • System: display, humidifier, compliance meter, data storage/retrieval

• Apply continuously, semi-continuously, or just in sleep?

• Is therapy working adequately?

• Added Oxygen? Humidification? Chin strap? Posture?
Noninvasive PAP Therapies

Indications

• Postoperative sleep disordered breathing
  — Obstructive sleep apnea
  — Central sleep apnea

• Postoperative hypoventilation
  — May be related to underlying comorbid conditions (i.e. COPD, OHV)
  — May be related to anaesthetics, opioids and sedatives

• Postoperative hypoxemia
Noninvasive PAP Therapies

Contraindications

- Respiratory arrest
- Shock
- Uncontrolled cardiac ischemia or arrhythmias
- Inability to protect the airway / excessive secretions
- Severe upper GI bleeding
- Facial trauma, burns, anatomic abnormalities
- Agitated or uncooperative
- Severely encephalopathic
Modalities of Noninvasive PAP

• Continuous Positive Airway Pressure (CPAP)
  – Can be a fixed pressure
  – Can be set in autoadjusting mode (pressure range is set).
    Aka ACPAP or APAP.

• Bilevel Pressure Support (BPAP)
  – Separate inspiratory (IPAP) vs expiratory (EPAP) pressures
  – IPAP – EPAP = level of pressure support. Can use a backup rate.
  – Can be fixed pressures (set IPAP and EPAP)
  – Can be pressure ranges for each (IPAP range, EPAP range)
    AKA autoBPAP or ABPAP

• Variable Pressure Support (ASV)
  – Counteracts breathing periodicity in an antidromic fashion by
    varying the amount of pressure support based on the flow
Noninvasive PAP Therapy

**Continuous Positive Airway Pressure (CPAP):** Breathing on a fixed pressure setting.

**Bilevel Positive Airway Pressure (BPAP):** Breathing on 2 pressures = IPAP, EPAP. PS = IPAP-EPAP.

**Synonyms:**
- non-invasive ventilation (NIV)
- nasal IPPV (nIPPV)
- non-invasive IPPV (nIPPV)
- non-invasive pressure support
- bi-level pressure support
- BiPAP®
- VPAP®

**Adaptive Servo Ventilation (ASV):** The amount of pressure support varies by flow. More support for lower flow, and vice versa.
Purposes for Noninvasive PAP

Continuous Positive Airway Pressure (CPAP)
- End Expiratory Pressure (PEEP, EPAP)
  - Pneumatically splints the upper airway
  - Recruits alveoli
  - ↓ right ventricular preload, ↓ left ventricular afterload
  - Counteracts intrinsic PEEP

Bilevel Pressure Support (= IPAP – EPAP) (BPAP)
- Provides mechanical ventilatory assistance
- Relieves some of the work of breathing
- Stabilizes the chest wall

Variable Pressure Support (ASV)
- Counteracts periodic breathing patterns
Potential Indications for Noninvasive PAP Modalities

• **Continuous Positive Airway Pressure (CPAP)**
  - Obstructive sleep apnea (OSA) / upper airway obstruction
  - Central sleep apnea (CSA) (*in specific cases*)
  - Hypoxic respiratory failure / alveolar recruitment / pulmonary edema
  - *ACPAP should only be used in OSA*

• **Bilevel Pressure Support (BPAP)**
  - OSA
  - CSA (usually with a back up rate)
  - Hypoventilation (i.e. COPD, neuromuscular disease, OHS, meds)
  - Hypoxic respiratory failure (often with hypoventilation)
  - Flail chest

• **Variable Pressure Support (ASV)**
  - CSA with Cheyne-Stokes breathing
    (**cardiac ejection fraction must be > 45%**) 
  - CSA due to opioids
Implementing Therapy: **Interface Choice**

**Face Mask vs. Nasal Mask**

A. Total Face Mask
   - unable to use face mask
   - leaking with other masks

B. Full Face Mask (with anti-asphyxia valve)
   - acute disease
   - naïve patients
   - facial weakness
   - high respiratory impedance
   - nasal obstruction

C. Nasal mask or

D. Nasal pillow mask (± chin strap)
   - less intrusive
   - long term use

*Choice balances control vs. comfort/safety*
Implementing Therapy: Choice of Ventilator

• Flow generators
  - Classic ventilator that is used noninvasively
  - Deliver a constant volume despite changing impedance

• Pressure generators
  - Leak compensation is inherent
  - Peak airway pressure limited
  - May be better tolerated
  - Types:
    • Basic: home use, basic hospital use
      • May have one or several modes
        • CPAP – fixed pressure that can be adjusted, autotitrating
        • BPAP – spontaneous, spontaneous timed, autotitrating
        • ASV
    • Advanced: generally used in the PACU or ICU settings
      • Additional modes, better displays, oxygen blenders
Ventilator Settings (I): Modes of Operation

• CPAP

• BPAP - Spontaneous
  • Basic need is for CPAP but some pressure assistance needed (e.g. OSA + morbid obesity) or there is intolerance of CPAP
  • Cheaper than S/T (and thus should always use ST if possible)

• BPAP - Spontaneous/Timed (S/T)
  • Where mandatory back up breathing rate is needed (e.g. central apneas or in some hypoventilation cases)

• BPAP - Timed
  • Gives direct control by supplying timed breaths only
  • Well tolerated in conditions of low impedance and/or low drive (e.g. respiratory muscle weakness)

• ASV – antidromic pressure support with a back up rate
Ventilator Settings (II): Pressures

- **EPAP (CPAP)**
  - Usually 5-10 cm H$_2$O but can go up to 20 cm H$_2$O (*though 18-20 cm H$_2$O usually poorly tolerated*)
  - Minimum 4 cm H$_2$O with most NIV

- **IPAP** (*Pressure Support = IPAP – EPAP*)
  - IPAP <10 cm H$_2$O (*some consider this “homeopathic”*)
  - IPAP >20 cm H$_2$O is associated with aerophagia, ↑ mask leaks, ↓ tolerance
  - Usual working range 12 to 20 cm H$_2$O:
    - Start at 12-14 cm H$_2$O, adjust to tolerance & blood gases
    - Sometimes 20 cm H$_2$O is not enough (*some devices go as high as 30 cm H$_2$O*)

- **Autotitration Modes**
  - Set titration limits
    - i.e. for autoadjusting CPAP 6-16 cm H$_2$O
    - For autoadjusting BPAP may need range for both IPAP and EPAP
Different devices have different capabilities & combinations of them:

• **EPAP**
  - May be autotitrated in BPAP or more advanced modes
  - Autotitrates to eliminate upper airway obstruction

• **Pressure Support**
  - Breathing Periodicity*
    • Adaptive Servo Ventilation (ASV)
      - Can adjust EPAP for obstructions and level of PS to stabilize flow
      * heart failure (with ejection fraction > 45%), cerebrovascular disease, opioid use, treatment-emergent central sleep apnea
      Hastings et al, 2010; Kasai et al, 2010
  - **Volume Assured Pressure Support (VAPS)**
    • Average Volume Assured PS (AVAPS® by Philips Respironics)
    • Intelligent Volume Assured PS (IVAPS® by ResMed)
      - Both devices can adjust EPAP for obstructions and level of PS to achieve a predetermined tidal volume or alveolar ventilation

The future: an intelligent machine that defines and treats the breathing disorder?
Volume Assured Pressure Support (VAPS)

• Used for conditions of *usually progressive* hypoventilation and less likely to be started during acute hospitalization

• AVAPS® (Philips Respironics)
  – Predetermine the target tidal volume (8 ml/Kg (ideal body weight))
  – Set IPAP limits to achieve the targeted tidal volume
  – Respiratory rate 2-3 BPM below resting
  – Set the Inspiratory Time
  – Set the Rise time

• IVAPS® (ResMed)
  – Predetermine the target alveolar ventilation*
  – Set IPAP limits to achieve the targeted alveolar ventilation
  – Adjust values for condition to be treated: adjusted/individualized during wakefulness
  * mathematical allowance for dead space

* mathematical allowance for dead space

Canpolat et al, 2014; Kelly et al, 2014
Ventilator Settings (III): Rate, Within Breath Timing, Comfort

• Rate
  – S/T mode: dictates length of expiratory pause before a mandatory breath is given (usually set at 80% of resting rate)
  – Timed mode: patient comfort in specific cases (set ≈ resting rate)

• Within Breath Timing
  – Ti usually set to 40% of Ttot (I:E ratio = 1:1.5)
  – Increase Ti to augment gas exchange
  – Decrease Ti in presence of hyperinflation (need more time to exhale)
  – Can only adjust Ti (min) in case of triggered breaths

• Comfort Settings
  – Delayed “rise time”: slows inspiratory onset, avoid with high RR
  – Expiratory pressure release / flex control: temporarily drops pressure during exhalation for comfort
  – Ramp: slowly increases pressures over time to prescribed settings
Within Breath Timing: BPAP in a Case of Duchenne M. Dystrophy

Spontaneous/Triggered (at Ti min) aroused or awake (A)
Timed (at Ti max) asleep (B)
Both are too short for a patient with neuromuscular disease (look at the waveforms)
Ventilator Settings (IV):
Alarm, System Settings, Display

• Alarms
  – Apnea
  – Disconnect
  – Low Minute Ventilation
  – Low Tidal Volume (AVAPS)
  – Power Failure (with uninterruptable (battery) power supply)

• System Settings / Display
  – Backlight, Language, cm H2O vs Kpa
  – Humidifier settings
  – Compliance, Pressure, Leak, Efficacy
  – Tidal Volume, Respiratory Rate, Minute Volume
  – Oxygen Blender / FiO₂ / Oximetry (only with certain devices)
Hours of Use: Continuous, Semicontinuous or Only With Sleep

• Continuous/Semicontinuous Therapy
  – Acute Respiratory Failure
    • Marked imbalance between load on the respiratory system and capacity to breath against it
  – Breaks from Noninvasive PAP dictated by:
    – Ability to comply with therapy
    – Rate of rise of PCO$_2$ and/or capacity to sustain SaO$_2$ when taken off therapy
  • *Must keep invasive ventilation under consideration if failing*

• Sleep Therapy (± episodic daytime use)
  – Chronic Respiratory Failure
  – Resolving Acute Respiratory Failure (weaning)
  – Sleep Disordered Breathing
Judging Adequacy of Therapy

• Symptoms / side effects
  - Patient comfort, mental state

• Signs
  - Heart rate, respiratory rate, chest wall displacement, use of accessory muscles
  - Synchrony with ventilator
    • leaks, upper airway obstruction, patient effort, trigger sensitivity (+/-)

• Acute indications: Wakeful arterial blood gases
  - Measure at 1-2 hours, then 4-6 hours if little improvement (pH important)

• Chronic indications: Ventilation during sleep
  - SaO$_2$: % sleep time at SaO$_2$ <80%  (= PaO$_2$ 45 mmHg)
  - Transcutaneous pCO$_2$ (if available)
  - Waking ABGs
Adjunctive Treatments

- **Oxygen**
  - If adequate CO$_2$ control but persistent hypoxemia despite adjusting ventilatory parameters
  - 1-2 L/min or more to the mask, titrate against SaO$_2$ and pCO$_2$
    
    (aim for SaO$_2$ of 88 – 92% in COPD patients)

- **Chin Strap**
  - May help with mouth leaks when using a nasal interface

- **Humidification**
  - Useful for persistent dry mouth and/or rhinitis despite chin strap

- **Posture**
  - Elevate the upper body for obesity and diaphragmatic weakness
  - Lateral posture may help in patients with OSA, scoliosis, or s/p thoracoplasty
Conclusions

Non-Invasive Ventilation continues to evolve:

• Expanding role in perioperative care

• Advances:
  – More sophisticated therapy modes are now available
  – Less intrusive masks, simpler devices, better comfort settings
  – Increasing autotitrating capacities

• We have a better understanding of pathophysiology and optimal use of therapy *(right modality, right patient)*

• Use can improve the patient’s quality of life

• There is an increasing capacity to tailor therapy to facilitate transfers between PACU, ICU, the ward, and home

• Use may also lead to reduced hospital length of stay, readmission, ICU admissions, and even mortality
Further Reading


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http://www.sasmhq.org

Thank You!