Biphasic Cuirass Ventilation (BCV) Algorithm of Care

Initial Assessment/Indications

Criteria:

- Respiratory failure (hypercarbic/hypoxemic)
- P/F ratio less than 350 or falling
- Pt requires high flow or high Fi02 device.
- Maintainable airway (airway adjunct or CPAP can facilitate)
- Stable hemodynamics
- Need for lung volume expansion or recruitment
- Able to tolerate cuirass (mild sedation or anxiolytic on early uses may facilitate)

Relative Contraindications/Cautions:

- PaO2/FiO2 ratio <100 unless combined with positive pressure
- Lack of viable airway. (Can be maintained naturally, with adjunct, CPAP or HFO2)
- Unable to obtain an effective/comfortable seal to body
- Burned skin, draining wound or excoriations under cuirass
- Lines tubes or drains with point of entry under cuirass seal
- Weight >180kg
- Cardiopulmonary Arrest
- Pregnancy or severe abdominal distension

1. Mode Selection and Setup

Mode	Patient Condition	Starting Parameters	Notes
CNEP	Early hypoxemia Falling P:F ratio <350 HFO2 or FiO2 >.4 started Atelectasis ↑work of breathing Hypercarbia with respiratory drive intact	-8 to –15	Start at -20 for severe hypoxemia or significant atelectasis, titrate to –40 prn, wean with improvement. May combine with NIPPV, PPV, or any source of O2 supplementation prn
Control	Severe respiratory failure pH>7.2, WOB, CO2 retention refractory to CNEP Weak or absent respiratory drive	-21/+7, I:E 1:1 RR 2-4 above spontaneous	ΔP >10 cm to max(ΔP=PNIP+PPEP) Lower MCP for hypoxemia by inverse ratio timing Increase delta and rate for hypercarbia May combine with PPV May require anxiolytic or sedation to obtain initial synchronization
Respiratory Synch.	Persistently asynchronous in Control Mode but has adequate respiratory drive Weak effort, needs assist Non-hypoxemic SpO2 > 92 on FiO2 <.4	–21/+7 Sensitivity 4–5 adjusted to achieve 85-100 trigger%	Similar to CPAP/PS Patient resp pattern sets I:E Difficult to manage MCP thus may have little benefit for improving hypoxemia
Secretion Clearance	Retained pulmonary secretions or high potential	800 cpm @ 25cwp x 4 mins Cough –30/+25 x 24/min 1-2 min Repeat x 3-5	q3-4h w/a & prn Decrease duration of oscillation if pt dependent on Control mode

2. Monitoring & Titration

Paremeter	Goal	Notes
SpO2	92-97%	Evaluate SpO2/PaO2 response. Typically improves as greater alveolar surface area is created. May dip initially as un-perfused, freshly recruited alveoli gain perfusion. Primarily benefitted by mean cuirass pressure (MCP). Hyperoxia should be minimized. Decrease FiO2 to .4 and minimize PEEP before decreasing MCP.
PaCO2/PtcO2/ETCO2	Within normal range for patient	Can decrease with CNEP as WOB and metabolic rate decreases. In Control, increase ΔP and or rate if above desired range. Decrease if paCO2 if below. Hyperventilation quickly possible with increased recruitment and alveolar ventilation.
Breath Triggering %	85-99%	=% of breaths delivered triggered by patient of total. Suspect auto-cycle if 100%. Suspect missed efforts if at or below 85%. Adjust sensitivity. Lower value more sensitive.
Mean Cuirass Pressure	Less neg than -4 in Control	MCP more negative to increase end expiratory lung volume/recruitment in CNEP and Control. In Control increase by inverse I:E.
Patient Comfort	Minimal dyspnea Comfortable fit	Properly adjusted parameters will generally improve breathlessness. Foam seal should allow comfortable seal to body. At extreme levels of pressure or beginning use of mild analgesic, anxiolytic or sedation provides effective means of helping patient become used to therapy. With significant pain, reevaluate fit.
Rad Studies/EIT/Lung US		Clinical markers of increased aeration should be recognizable, in 1-24 hours.

3. Integration with PPV (Tandem operation)

Recommended configurations	PPV with CNEP	Set PPV as per normal protocol with CNEP to manage aggressive recruitment or to normalize FRC. If pPlat or MCP increases, decrease PEEP by half or completely. CNEP will manage FRC. Restore PEEP when cuirass removed. Aids recruitment and P:F.
	BCV in Control with CPAP	Set BCV per guidelines with minimal PEEP for accurate VT monitoring with BCV cycling. Goal VT 5-8 ml/kg.
	BCV in Control with AC/VCV	Set PPV rate < BCV rate with goal of 1:1 synchrony. If MAP or pPlat increases, decrease PEEP. Max CO2clearance.

4. Stepwise Use of BCV as Tool to Wean From PPV

Step 1 Verify patient meets standard criteria for SBT

Step 2 Approximately 12-24 hrs prior to SBT begin lung recruitment with BCV

a. Secretion clearance with oscillation: Set at 600-800 c/m for 4 mins f/b cough assist for 2 mins repeated x 5 for total of 30 mins q4h with gentle suctioning during final seconds of cough assist cycles. Can be applied with patient on or off PPV.

b. Lung recruitment: In conjunction with patient's normal PPV resting settings apply BCV in CNEP at -10 to -15cm. Once CNEP established consider decreasing PEEP on PPV by half as tolerated. (PEEP and CNEP are both sources of augmented RV and PIPs may increase unless PEEP decreased. If PIPs or Pplat increased with PEEP halved decrease to 0. (restore to previous levels whenever cuirass removed)

Step 3 Establish rest and recovery settings for BCV: BCV can be utilized to rest patient post extubation or between weaning sessions, if signs of fatigue develop or if nightly rest is desired. It works very well to titrate BCV for rest while patient is still connected to PPV in order to verify volume exchange and BCV settings required.

a. With patient on PPV place in AC with standard VT 6-8 ml/kg. Set RR low so patient is triggering most breaths.

b. To titrate BCV for rest initiate Control Mode at rate equal to or slightly greater than rate patient is triggering PPV.

c. Initiate pressures at -24/8 with 1:1 I:E. BCV will take a few minutes to ramp to those pressures. When at about -20 insp press, adjust PPV to CPAP with CPAP of 3 and PS titrated to achieve VT equal to resting VT that was used in AC.

d. Once BCV reaches -24/8, PS should be able to be decreased and volume maintained.

e. Goal is to decrease PS to 5-8cm or ATC if available, while maintaining 6-8ml/kg. If unable to decrease PS to this level greater span or ΔP is required.

f. Increase or decrease BCV span incrementally by 2-3 cm until return volumes are in desired range (span <20cm very rare, always verify MCP more negative than -4cm at rates <60/min).

g. Once this is reached this will be the resting BCV setting levels. Patient should be allowing BCV to support them for the most part. This can be seen by a 1:1 capture of BCV cycles from the PPV. These settings will remain in memory and can be utilized prn need for rest.

h. Monitoring of ETCO2 or an ABG may be warranted as V/Q, O2 requirement or CO2 production can improve with BCV and patient may be hyperventilated after a period of use and rate may need to be decreased somewhat.

Step 4 Begin SBT when ready as per normal protocol for weaning technique, assessment and progressing except utilize CNEP -10 to -15 and utilize half normal or 3 cm CPAP level if using CPAP and not weaning via T-bar or T-collar.

Step 5 Progress weaning as per routine protocol with secretion clearance continuing q4h prn during active weaning and q4 & prn between SBTs. Utilize standard weaning termination criteria. Patient may be rested on standard PPV rest settings or preferably BCV with low CPAP with PS as previously titrated if tolerable.

Step 6 Once standard extubation/PPV d/c criteria met with BCV still in use, PPV can be d/c'd and extubation may be carried out while continuing utilizing BCV to support the process for SBTs and resting.

Step 7 With demonstration of continued tolerance CNEP can be adjusted by 1-2 cwp incrementally until at -5.

Step 8. If patient able to tolerate -5 without difficulty for 1 hour attempt placing BCV in standby. CNEP can be resumed prn returning to the -10 to -15 levels.

Step 9 If patient able to tolerate standby for 1 hour remove cuirass.

a. CNEP can be utilized prn for any signs of fatigue or on routine schedule with secretion clearance and cough assist as indicated, (this is a good strategy for patients prone to atelectasis and/or secretion retention problems).

b. Nightly rest may be and usually is desirable using BCV as previously titrated with ongoing secretion clearance needs being met as well with oscillation and cough assistance.

d. Contact Hayek Medical at 855 2 GET BCV (855-243-8228) to assist with discharge planning to provide BCV for long-term home use to prevent readmission for assistance in utilizing BCV for weaning from PPV or any clinical situation, please contact your Hayek Clinical Specialist

5. Weaning From BCV

Step 1 When patient able to advance to CNEP with good tolerance decrease CNEP to -5 to -8.

Step 2 Return to higher level of support if intolerant as demonstrated by decreased below. ↓SpO2, ↑HR & RR or level of comfort.

Step 3 When able to tolerate -5 to -8 for one hour on FiO2 < .4 remove place cuirass in standby.

Step 4 Monitor for tolerance. If off for 30 mins to 1 hour with good tolerance, remove cuirass.

Step 5 May rest nightly and prn for fatigue development or re-recruitment.

6. Alternate BCV Wean Approach

Cuirass is to be removed q4-6 hours for skin assessment and seal check/replacement. During removal the patient may need alternative support but will generally tolerate brief removal without difficulty. When goals of therapy are reached, duration of removal can be increased, limited by patient status until BCV able to be placed on standby. Use for rest or FRC normalization prn.

7. Escalation to More Intensive Intervention: Intubation, PPV or ECMO

Indication	Threshold	Notes
Refractory Hypercarbia	PaCO2 > 90 or pH < 7.15	Significant gas exchange compromise can respond to BCV application. Combine Control with PPV for max CO2 clearance. BCV will facilitate safe lung volume maintenance and restoration during ECMO use and discontinuance.
Refractory Hypoxemia	P:F ratio nonresponsive to BCV	Observable improvement in P:F or S:F ratio should occur within 6-48 hrs
Hemodynamic Instability	MAP < 65 or Bradycardia	Patients may demonstrate mild hypotension when initially getting good sleep with BCV.
Unable to achieve good seal	Inability to achieve cuirass pressures	Removing and replacing cuirass or relacing seal may improve fit.
Loss of airway control	Airway patency required	Airway adjuncts, HFO2 or combining BCV with NIPPV/CPAP can potentially restore airway patency.

Long-Term/Home BCV Management

Scenario	Mode	Recommendation
Nightly rest/Continuous Use (NMD/COPD/restrictive)	Control, Resp Sync or CNEP	Titrate from hospital baseline Set per Clinician's Guidebook
Chronic airway clearance needs	Secretion Clearance	20 to 30 min cycles BID to q4
Recurrent readmissions or atelectasis	CNEP nightly or intermittently	CNEP 2+ hrs 3/day to continuous
Coordinate home BCV setup	Contact Hayek Medical 8552GETBCV (855 243-8228)	Hayek will coordinate with DME

Notes:

1. Concepts abbreviated for algorithm. Clinicians must review BCV Clinician's Guidebook and have Introduction to BCV training for complete concepts and thoroughly understand function and use of the Hayek BCV device.
2. Inverse ratio ventilation safer with BCV due to active exhalation and often needed to support lung volume enhancement in Control.
3. Monitor for airway clearance needs and use Secretion Clearance treatment mode prn**.** Prepare for more suctioning/expectoration.
4. Secretion Clearance mode goes to standby when completed. If supporting mode required, manual adjustment and Start is needed.
5. Mean Cuirass pressure should be managed to more negative than -4 in Control and CNEP. MCP target achieved best by starting at 1:1.
6. BCV will combine with any form of form of O2 or vent support; however volume targeted modes may be inconsistent with BCV Control.
7. Patents who successfully use BCV as inpatients are likely candidates for use in the home.
8. Contact your Hayek Clinical Specialist for assistance with questions on patient's appropriateness for therapy as well as simple to complex care with BCV as early as possible and for home referral support.
9. The content provided by Hayek Medical's educational material is for informative purposes only and not intended to serve as a substitute for diagnosis, treatment and judgement by/of a qualified physician or healthcare professional.