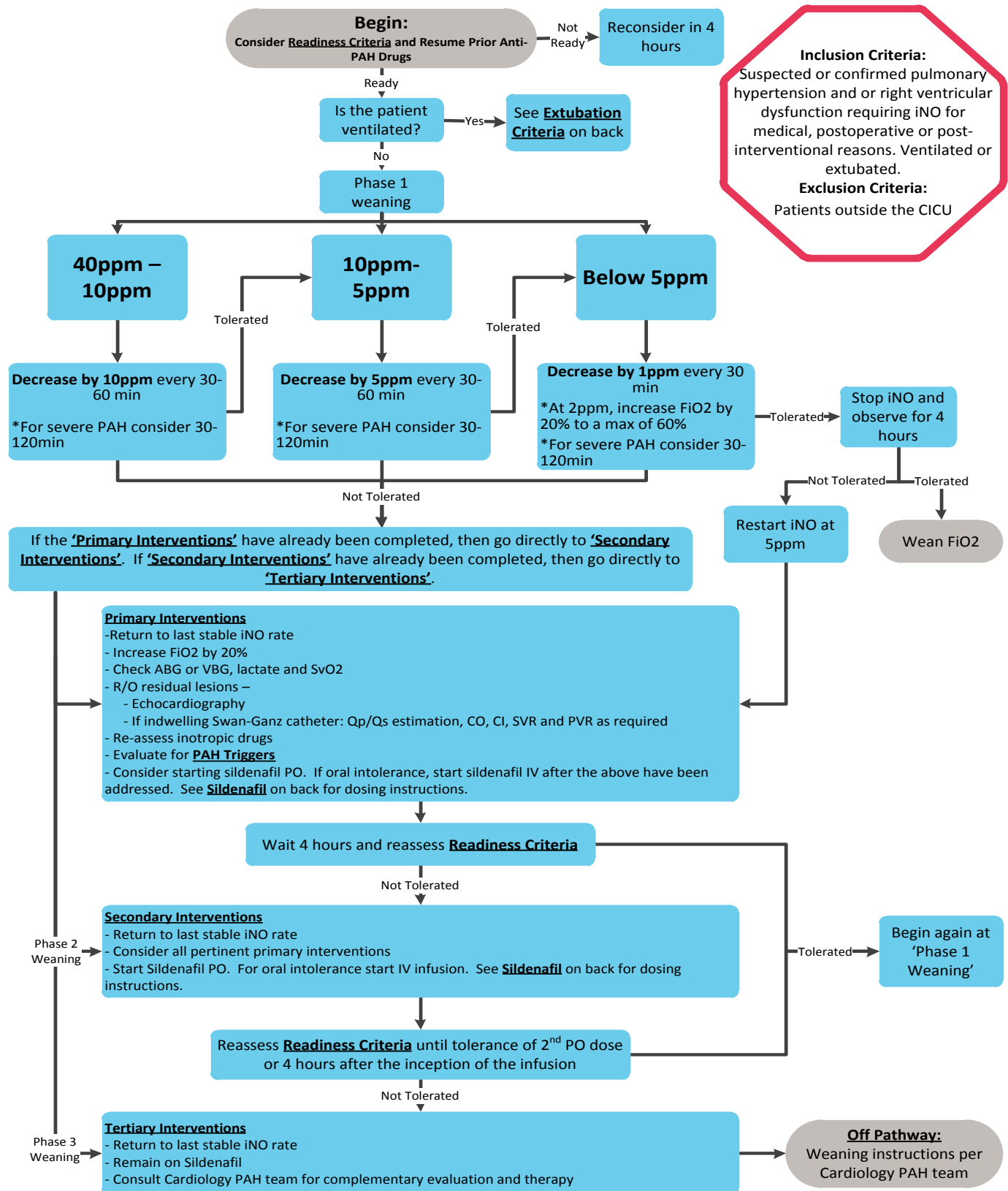


# Inhaled Nitric Oxide (iNO) Weaning in the CICU

## ALGORITHM



**Extubation Criteria:**

If ventilated, iNO less than or equal to 20ppm and adequate readiness criteria

- Consider extubation and
- Administer latest iNO rate X2 via nasal prongs upon extubation
- Wean iNO per algorithm at Phase 1

**Readiness Criteria for Starting iNO Wean:**

**Key Factors –**

- FiO2 less than or equal to 60%
- Hemodynamically stable for greater than or equal to 6 hours
- No PAH triggers

**Ancillary Factors –**

- MPAP less than or equal to 50% MAP
- Normal Lactate
- DavO2 less than or equal to 30

**Weaning Tolerance Criteria:**

- 20% or less decrease in PaO2 **-OR-** 10% or less decrease in sPO2 **AND** FiO2 less than or equal to 60%
- No PAH rebound (MPAP less than or equal to 50% MAP)

**PAH Triggers (selected):**

- Volume overload/pulmonary edema
- Anemia
- Pain/agitation
- Acidosis

**Sildenafil:**

Start sildenafil PO with a goal of 1mg/kg/dose q6-8 hours:

- 1<sup>st</sup> dose of 0.5mg/kg (max dose 10mg)
- 2<sup>nd</sup> dose of 0.75mg/kg (max dose 15mg)
- 3<sup>rd</sup> dose of 1mg/kg (max dose 20mg)

For oral intolerance start sildenafil IV:

- Less than or equal to 15kg:
  - 0.07 mg/kg/hr
- More than 15kg - Intermittent IV infusion with a goal of 0.5 mg/kg/dose every 8 hours:
  - 1<sup>st</sup> dose of 0.25 mg/kg (max dose 5mg)
  - 2<sup>nd</sup> dose of 0.38 mg/kg (max dose 7.5mg)
  - 3<sup>rd</sup> dose of 0.5 mg/kg (max dose 10mg)

## TABLE OF CONTENTS

[Algorithm](#)

[Target Population](#)

[Background | Definitions](#)

[Initial Evaluation](#)

Clinical Management – [See Before, During, After Weaning](#)

[Laboratory Studies | Imaging](#)

Therapeutics – [See Before, During, After Weaning](#)

Parent | Caregiver Education – N/A

[References](#)

[Clinical Improvement Team](#)

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## TARGET POPULATION

### Inclusion Criteria

Suspected or confirmed pulmonary hypertension and or right ventricular dysfunction requiring iNO for medical, postoperative or post-interventional reason. Ventilated or extubated.

### Exclusion Criteria

Patients outside the CICU

## BACKGROUND | DEFINITIONS

### Background:

- Medical, postoperative or post-interventional cardiac patients in need of iNO require cautious and yet assertive weaning of the latter in order to preserve hemodynamic stability and avoid potentially life-threatening rebound pulmonary hypertension
- There is a need for consistent and objective practices for the iNO weaning process
- Use iNO with caution in patients with suspected Pulmonary Venous Obstructive Disease (PVOD) or left ventricular dysfunction as it may increase pulmonary capillary blood volume leading to pulmonary edema and/or enhance the severity of the patient's heart failure
- Use of iNO in patients with Right-to-Left dependent blood flow may be contraindicated
- Goal is to safely wean the iNO as soon as deemed possible and safe
- Consider that abrupt discontinuation of iNO may cause rebound pulmonary hypertension
- Before weaning, patients must:
  - Fulfill "Readiness Criteria"
  - Be free of "Pulmonary Arterial Hypertension (PAH) triggers"
- Extubation is to be considered if the patient fulfills the "Extubation Criteria"
- Weaning guidelines are based on a three phase algorithm

## Definitions:

- iNO - Inhaled Nitric Oxide
- FiO<sub>2</sub>- Inspired oxygen fraction
- DaVO<sub>2</sub>- Arterial-venous oxygen difference/oxygen debt
- PaO<sub>2</sub> – Partial pressure of oxygen
- sPO<sub>2</sub>- Peripheral capillary oxygen saturation
- SvO<sub>2</sub>- Mixed venous oxygen saturation
- PAP - Pulmonary Artery Pressure
- PAH- Pulmonary Arterial Hypertension
- PwP- Pulmonary Wedge Pressure
- PVR- Pulmonary Vascular Resistance
- MAP- Mean Arterial (systemic) Pressure
- MPAP – Mean Pulmonary Artery Pressure

## Extubation Criteria:

If iNO less than or equal to 20ppm and adequate readiness criteria:

- Consider extubation and
- Administer latest iNO rate X2 via nasal prongs upon extubation
- Wean iNO per algorithm at Phase 1

## Readiness Criteria for Starting iNO Wean:

- Key Factors
  - FiO<sub>2</sub> less than or equal to 60%
  - Hemodynamically stable for greater than or equal to 6 hours
  - No PAH triggers
- Ancillary Factors
  - MPAP less than or equal to 50% MAP
  - No lactic acidosis
  - DavO<sub>2</sub> less than or equal to 30

## Weaning Tolerance Criteria:

- 20% or less decrease in PaO<sub>2</sub> –OR – 10% or less decrease in sPO<sub>2</sub> –AND- FiO<sub>2</sub> less than or equal to 60%
- No PAH rebound (MPAP less than or equal to 50% MAP)

## PAH Triggers (selected):

- Volume overload/pulmonary edema
- Anemia
- Pain/agitation
- Acidosis

## INITIAL EVALUATION

- Oxygen Saturation
- MPAP, PwP
- Vital Signs - Systemic BP, HR, RR
- Color
- Perfusion
- Near Infra-Red Spectroscopy (NIRS)
- SvO<sub>2</sub> and DaVO<sub>2</sub>

## LABORATORY STUDIES | IMAGING

- Echocardiography to assess for signs of PAH, ventricular function, cardiac repair and to rule-out residual lesions
- ABG to assess pH, ventilation and oxygenation
- Lactate and SvO<sub>2</sub> to evaluate tissue perfusion and DaVO<sub>2</sub>
- CXR to assess lung expansion and to rule out intra-thoracic “PAH triggers”
- Bed-side hemodynamic evaluation via the Swan-Ganz catheter (Qp/Qs, MPAP, PwP, CO, CI, PVR, SVR), the trans-thoracic pulmonary catheter and/or the left atrial catheter when indwelling

**Note: patients with persistent iNO-dependent PAH and/or hemodynamic instability and/or suspicion of residual lesions, may require a cardiac catheterization prior to weaning the iNO**

## BEFORE WEANING THE iNO:

- In patients with prior medical therapy for PAH, home medications should be resumed before weaning, as long as tolerated by enteral or parenteral administration
- Maintain adequate ventilation, oxygenation, and pH; Hypoxia, Hypercarbia, and acidosis may increase PVR and worsen PAH
- Avoid agitation and stressful procedures during weaning of iNO
- Consider extubation if fulfilling “Extubation Criteria”; if applicable, double the latest amount of iNO (in ppm) via nasal prongs
- Maintain stable hemodynamics
- Assess iNO Weaning “Readiness criteria”

## DURING THE iNO WEANING:

- Evaluate “Weaning Tolerance Criteria”
- **Phase 1** weaning includes completion of the primary interventions with the first round of non-tolerance of sequential reduction of iNO:
  - Return to last stable iNO rate
  - Increase FiO<sub>2</sub> by 20% to a maximum of 60%
  - Check ABG or VBG, lactate and svO<sub>2</sub>
  - Rule out residual lesions
    - Echocardiography
    - If indwelling Swan-Ganz catheter: Qp/Qs estimation, CO, CI, SVR and PVR as required

- Re-assess inotropic drugs
- Evaluate for “PAH Triggers”
- Consider starting Sildenafil PO or IV after the above have been addressed
- Wait 4 hours, then reassess “Readiness Criteria” and begin again at Phase 1 weaning if ready
- **Phase 2** weaning includes the consideration of all primary interventions and starting sildenafil with the second round of non-tolerance of sequential reduction of iNO according to the following schedule:
  - Start PO sildenafil with a goal of 1mg/kg/dose every 6-8 hours (see algorithm above)
  - For PO intolerance, start IV sildenafil (see algorithm above)
  - Wait for tolerance of the second dose or at 4 hours after the inception of the IV infusion reconsider the “Readiness Criteria” and begin again at Phase 1 weaning if ready
- **Phase 3** weaning includes consideration of the primary interventions, continued Sildenafil, and consultation of the Cardiology PAH team with the third round of non-tolerance of sequential reduction of iNO

### AFTER THE INO WEANING:

- Continue to assess weaning tolerance criteria for 4 hours
- If stable, start weaning FiO<sub>2</sub>

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Scheduled for full review on September 13, 2020

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