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Nursing Care of Children on Inhaled Nitric Oxide (iNO) Therapy in Cardiac Surgery and Its Pathway

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ABSTRACT

In India almost I in 100 children are with congenital heart defects. Perioperative management of pulmonary hypertensive crisis is an important focus in post cardiac surgery children, of which iNO is a vital treatment modality. Nursing care pathway facilitates the independence and timely intervention to obtain this positive outcome and prevent complications.

Keywords: Nursing care, Inhaled Nitric Oxide (iNO) Therapy, Cardiac Surgery

INTRODUCTION

In India almost one in 100 children are with congenital heart defects. Perioperative management of pulmonary hypertensive crisis is an important focus in post cardiac surgery children, of which iNO is a vital treatment modality1[1]. iNO stays as one of the significant management during the perioperative period in patients undergoing cardiac surgery under cardiopulmonary bypass[2]. Use of inhaled nitric oxide therapy has a significant effect on the clinical outcomes of children with pulmonary hypertension. FDA has approved the use of iNO in newborns with PPHN which reduces the need for ECMO [3,4].

Nursing care pathway facilitates the independence and timely intervention to obtain this positive outcome and prevent complications.

Mechanism of iNO as a selective pulmonary vasodilator

Nitric oxide is a selective pulmonary vasodilator and acts by inducing the smooth muscle relaxation only in a ventilated lung region (Figure 1) [1,3]. Inhaled nitric oxide improves oxygenation of blood and decreasing intrapulmonary right to left shunting. Understanding the mechanism of iNO as a selective pulmonary vasodilator will aid in better

Significance

- ✓ iNO is a specific pulmonary vasodilator, reduces right ventricular afterload & improves cardiac output
- ✓ Is a widely accepted standard of care for pulmonary hypertension management in cardiac surgery
- ✓ Reduced length of hospital stay.[1,5]

Uses

- To reduce pulmonary vascular resistance, and pulmonary artery pressure
- To optimize ventilation-perfusion matching- for the treatment of hypoxia, right ventricular dysfunction, pulmonary hypertension and graft failure in children and adult patients who underwent CPB

Indications:

I. Therapeutic applications of iNO therapy (General)

- ♦ Acute respiratory distress syndrome
- ♦ Chronic obstructive pulmonary disease
- ♦ Bronchopulmonary dysplasia
- ♦ Cardiac or lung transplantation

- ♦ Pulmonary hypertension during and after cardiac surgery

Ia. In post operative patients undergoing Cardiac surgery

- ✓ Severe Pulmonary Hypertension unresponsive to Milrinone or Sildenafil
- ✓ Pulmonary artery pressure (PAP) > 2/3rd systemic despite Milrinone or Sildenafil[7].

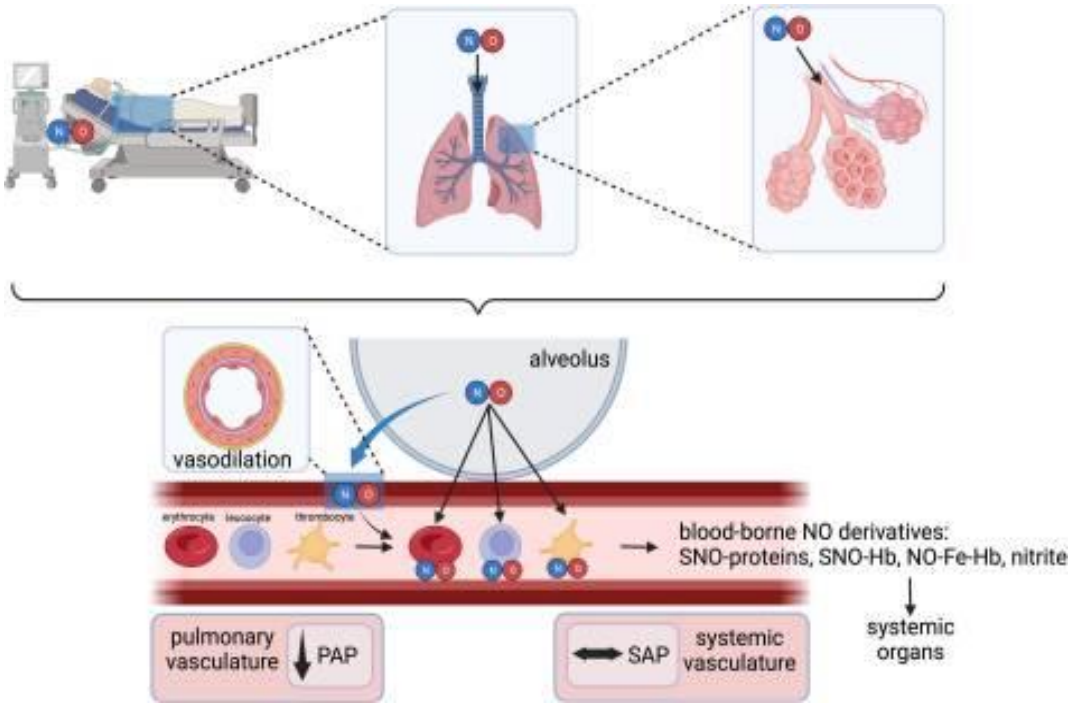

Figure 1. Inhaled NO as a selective pulmonary vasodilator and interactions with various blood components. NO, nitric oxide; PAP, pulmonary arterial pressure; SAP, systemic arterial pressure; SNO-Hb, S-nitrosohemoglobin; NO-Fe-Hb, ferrous nitrosyl-hemoglobin. Created with BioRender.com.

Duration and Recommended Parts Per Minute (* PPM)

Many studies recommend the use of NO therapy upto 24 hrs in the ICU including the time of surgery, whereas iNO can be extended even for weeks and longterm use of iNO is recommended as per the need.

Dose of iNO therapy **(*varies as per client's clinical condition- Intensivist's order)**

In 2005, a European expert council recommended that NO doses of 20 ppm or lower should be utilized in cardiac surgery patients, as doses greater than 20 ppm failed to show incremental benefit. In neonates and near-term neonates, the recommended dose for the treatment of PH associated respiratory failure is 20 ppm. To minimize the potential adverse effects, the minimal effective dose should be used. Often, doses lower than 5 ppm are effective

In children administered with inhaled NO for days to weeks at the dose of 5–40 ppm[3].

- 20ppmX8hrs
- 10ppmX 8hrs
- 5ppm X 8 hrs

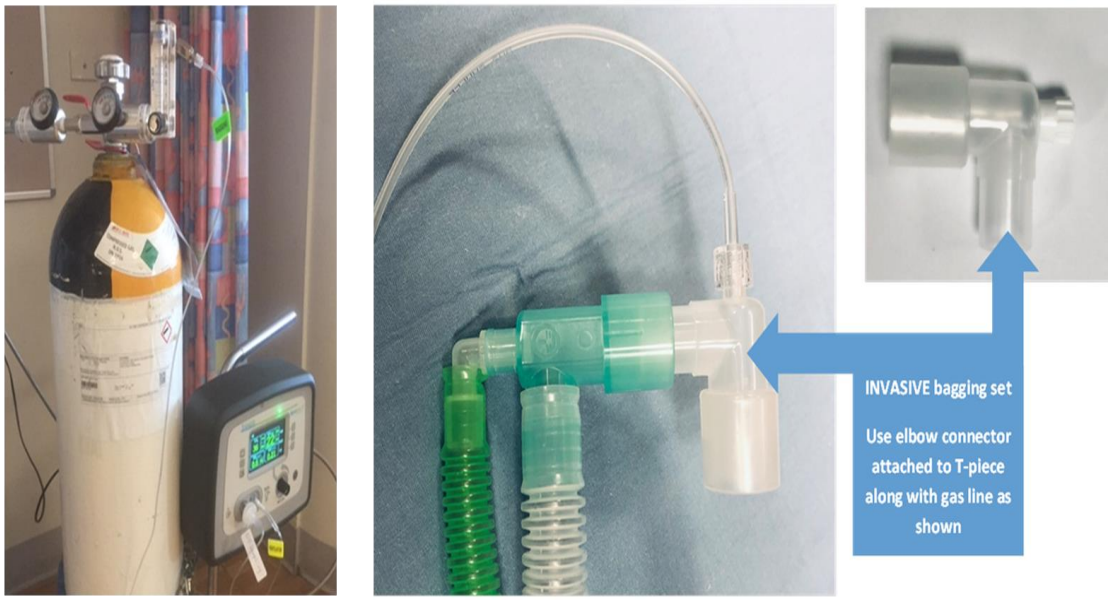

Figure 2. Inhaled nitric oxide circuit connection in ICU Source: Storage.googleapis.com -starship.org.nz

NURSING CARE OF CHILDREN ON INO THERAPY AFTER CARDIAC SURGERY

A. ASSESS

*Airway, ventilator settings since the iNO is delivered to the ventilated lungs.

Continuous monitoring of:

- ✓ Nurse needs to monitor the vital signs and the hemodynamic status of the child including heart rate, Pulmonary artery wedge pressure (PAWP), Arterial Blood Pressure (ABP), Saturation (SPO_2).
- ✓ Invasive lines- check the PAP pressure monitoring line, its circuit connection
- ✓ Methhemoglobunemia – Monitor Q6h ABG Methaemoglobin & NO_2 values and also whenever required[8,9].
- ✓ **If values are > 2.5, report Intensivist & STOP iNO**

B. Perform

- Closed ET suctioning as disconnection of tubing can also act as a trigger and can cause pulmonary hypertensive crisis.
- Connect Bagging circuit in iNO blender (Fig 2)
- Minimize trigger - pain, suctioning, position change, high temperature
- Sedate and paralyse the child

C. Communicate

The nurse needs to establish rapport with the child's parents, liase with the Intensivist & Child's parents on the need for therapy.

D. Report & Record

Documentation of child's response to the therapy, investigation reports and reporting of the significant events are recommended.

Weaning Prerequisite and Weaning from iNO therapy:

- Start weaning off from iNO if ABG PaO2 >90mm Hg
- Ensure Sildenafil infusion is onflow atleast for 2 hrs before weaning
- Keep emergency drugs ready;
- With hold NG feeds for atleast 6hrs
- slow decrease in the inhaled NO dose up to 1 ppm, with a contextual increase in the FiO2. (100). Imbrication with oral or intravenous pulmonary vasodilators (e.g., sildenafil, bosentan, and prostacyclin) can be taken into consideration to facilitate inhaled NO weaning.
- Reduce iNO PPM- *5 PPM / hr (*as per client's condition & order)
- Plan with multidisciplinary team (Surgeon, Intensivist)
- If child is not tolerating the weaning, reinitiate iNO if required & follow the earlier care aspects. [3,5,6]

Nursing care pathway for children on nitric oxide therapy following cardiac surgery is given in Fig 3

Potential adverse effects and challenges

1. Methhemoglobunemia- A condition in which there is an abnormal increase in methemoglobin levels and is the most commonly reported adverse event[4].
2. Resistance to iNO- resistance to iNO occurs due to various mechanisms such as impaired bioavailability of nitric oxide, alterations in downstream signaling pathway and underlying genetic factors[4]

CONCLUSION

The use of nitric oxide therapy plays a pivotal role in reversing the pulmonary resistance thereby enhancing the positive clinical outcomes in children undergoing cardiac surgery. Nursing care of child iNO poses a challenge yet demands skillful assessment, critical thinking and timely intervention for the anticipated result. Use of nursing care pathways in rendering nursing care to critically ill children provides a clear understanding of the nursing actions minimizing the time gaps in intervention promoting the autonomy among the multidisciplinary team.

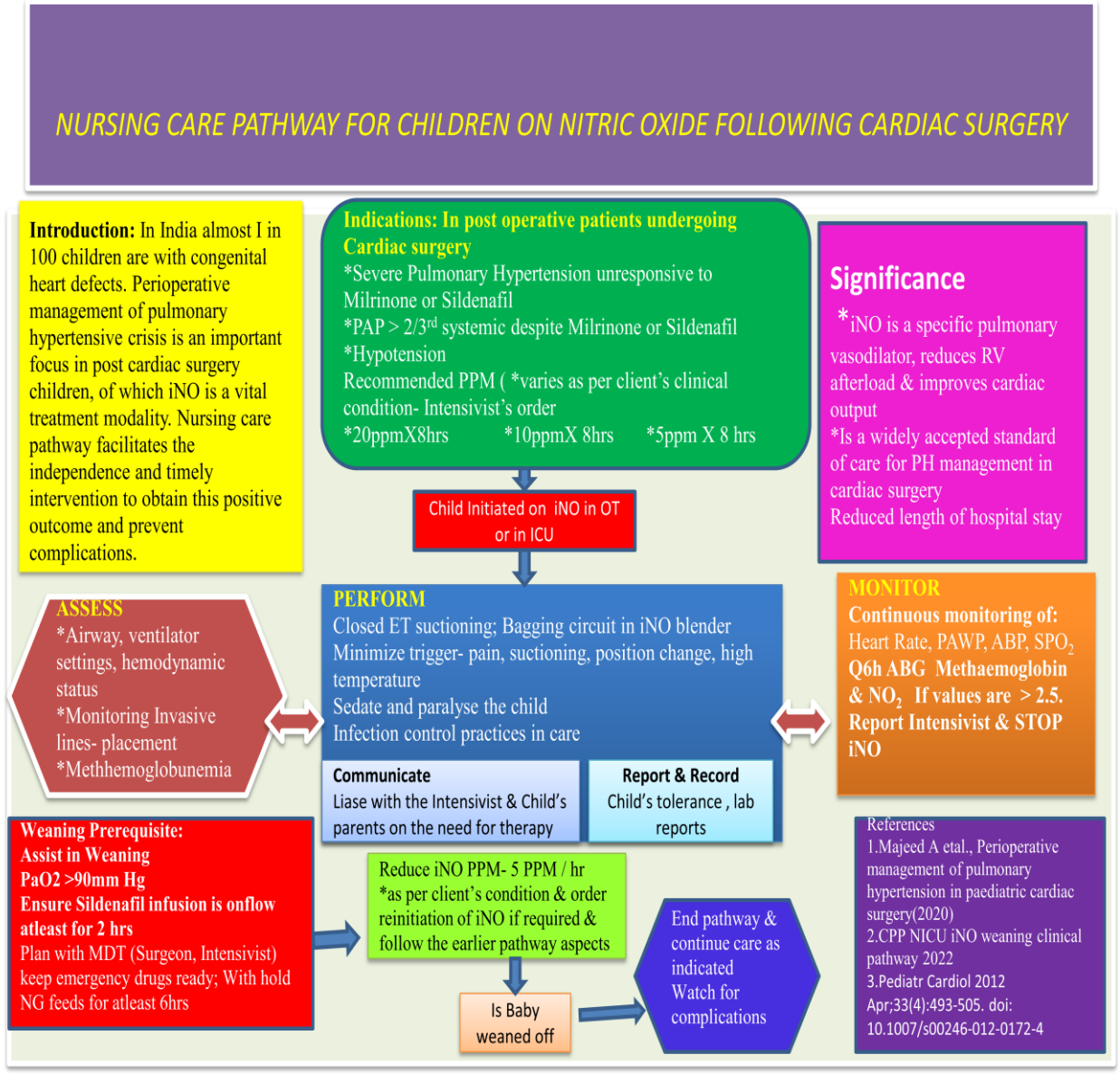

Figure 3: Nursing care pathway of children on nitric oxide therapy following cardiac surgery ***Source: Developed by the author based on clinical protocol and referred CPP NICU iNO weaning clinical pathway 2022***[6]

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