Peri-operative Guidelines for Neonates undergoing Norwood Operation

(items in Bold are part of the Guideline Adherence Score)

Pre-Operative Guideline to Prepare for Norwood Operation

Component	Guidance
Prior to surgery	• Identify pre-operative patient factors ○ Fetal intervention ○ Gestational age < 37 weeks ○ Birth weight < 2.5 kg ○ Genetic syndrome (suspected or confirmed) ○ Major extra cardiac abnormality or co-morbidity ○ Concerning anatomic and physiologic findings (Intact/restrictive atrial septum, mitral hypoplasia/aortic atresia, AAo < 2mm, > mild atrioventricular valve regurgitation, > mild ventricular dysfunction) ○ Pre-operative intubation ○ Other ○ None • Schedule the **pre-op discussion to occur before the day of surgery (either in the weekly surgical conference or ad hoc discussion with surgeon, anesthesiologist, CICU attending, Cardiologist, Echo attending present)** to: ○ Review anatomy and pre-operative factors/comorbidities ○ Outline an appropriate operative plan (subject to change depending on patient condition, test results, family discussion etc.) ○ Consider other strategies such as Hybrid procedure (or variation thereof) or non-intervention in higher risk cases – consider consulting the palliative care team • Document pre-operative patient factors and the discussion in that day's progress note • **Obtain a blood gas from a blood drawing venous catheter to assess acid-base status on the morning of the surgical date**
Surgical Team Planning	• Assemble OR team with the overall goal to balance expertise with Norwood operation across disciplines. ○ *Anesthesia to schedule Anesthesia attending/attending surgeon team* ○ *Surgery to coordinate fellow/physician assistant team. New fellow/resident should be 2nd assist for their first Norwood case* ○ *These assignments should be made the evening before surgery*

Intra-operative Guideline for Norwood Operation (p. 1 of 2)	
Component	**Guidance**

Monitoring	• **Non-invasive:**
	  ○ Telemetry
	  ○ Pulse oximetry
	  ○ Temperature probe (2 sites)
	• **Invasive**:
	  ○ **Arterial line** (umbilical arterial line preferred, arterial line in wrist contralateral to side of BT shunt)
	  ○ Umbilical venous line (either single or double lumen)
	  ○ Transthoracic right atrial line (2)
	  ○ Foley
	  ○ Ventricular Pacing wires

Access	• **2 points of intravenous access (combination of umbilical venous catheter and/or peripheral IV)** • **2 right atrial lines**
Anesthesia (Induction, during operation)	• Intraoperative anesthetic plan to allow for extubation between 24 - 48 hours. ***This plan should be reviewed with the CICU team during OR to CICU handoff***. • Suggest ventilator strategy that addresses potential causes of hypoxemia (eg., pulmonary vein desaturation)
Airway	• Nasal endotracheal tube • Inhaled nitric oxide available
Procedure	• Per pre-operative discussion • Modified ultrafiltration (if hemodynamics tolerate)

Intra-operative Guideline for Norwood operation (continued p. 2 of 2)	
Component	**Guidance**

Cardiopulmonary Bypass (CPB)	• **Prime CPB pump exclusively with fresh whole blood which would result in a Hct > 30%**
	• **Use FFP and PRBC's to prime the pump when whole blood not available**
	• Goal Hct ranges:
	  ○ 30% while on CPB (range of 28-32)
	  ○ 40-45% after MUF
	• Cool for 15 minutes, warm for 22 minutes
	• Rewarm to venous temperature of > 36°C or combined NP/ESO temperatures > 72
	• **Milrinone 100 micrograms/kg bolus in pump at the start of the 22 minute rewarming period**

Medications	• Milrinone – additional bolus doses as needed after coming off bypass • Dopamine – Low dose (1-3 mcg/kg/min) if needed • Ketamine – 0.15 mg/kg/hr • Dexmedetomidine - 0.2 mcg/kg/hr • Milrinone 0.2 mcg/kg/min • If patient needs > 3mcg/kg/min of Dopamine or any epinephrine, then consider further investigation depending on particular concern (TEE, cath., re-exploration, leaving chest open, ECMO, etc.) • **Anesthesia team to order Dexmedetomidine, Ketamine and IV Tylenol to be given when patient arrives in the CICU.** • **Anesthesia team to order Milrinone, epinephrine, dopamine, and inhaled nitric oxide to be available when patient arrives in the CICU.**

Hemostasis	• Amicar should be given to all patients
	• **The following blood products should be ordered and available when coming off bypass:**
	  ○ **PRBC**
	  ○ **Platelets**
	  ○ **Cryopercipitate**
	  ○ **Novo 7**
	• Coagulation labs – patient-specific depending on concern for bleeding.
	• Leave chest open if concern for bleeding with normal coagulation studies

OR to CICU Transition	
Component	**Guidance**
OR Team Debrief	• Post procedure debriefing among the OR team to highlight important intra-operative issues
OR to CICU Hand-off	• Attending surgeon, anesthesiologist, CICU attending, frontline clinician, CICU nurse *and the CICU attending on the other team* should be present at bedside to discuss the following: ○ The relevant details of OR course ○ **Highlight the main concern(s) for the overnight CICU team** ○ **Discuss candidacy for extubation over the next 24-48 hours** and state the strategies and goals (see post-op *Sedation* section in this guideline) ○ **When possible, the overnight CICU attending should also be present for the hand-off**
CICU Team Planning	• Assign CICU team for the patient with the overall goal to balance expertise with immediate (POD 0-2) post-Norwood care across disciplines. ○ *Nurse practitioners to assign front line clinician with experience caring for Norwood patients (either an NP or experienced senior cardiology fellow or 4th year CICU fellow)* ○ *Nursing to assign an experienced nurse at the bedside.* ○ ***Ensure senior provider (frontline and bedside nurse) is available for support when junior providers are assigned.***

Guideline for Post-Operative Days 0-2 after Norwood Operation (p. 1 of 3)			
Monitoring	**Guide**	**Worrisome Sign/Trend**	**Considerations**
Arterial Blood Gas (ABG) monitoring (for metabolic acidosis)	**For first 12 hours post-op, obtain ABG:** **On arrival** **Q 30 min x1 then** **Q 1 hour x2 then** **Q 2 hours** **Every other gas with lactate** Then, ABGs as needed	Base deficit: • Fall by 2 on consecutive gases or • Fall by 4 on one gas Need for NaHCO3 x2 Rising lactate	• CXR • Consider TTE to evaluate function, effusion, AVVR, aortic arch repair • Call to surgeon*
Oxygenation	Goal PaO2 35-45 Goal SaO2 70-85% (Of note, abnormalities in SpO2 can prompt initial investigation/therapy but should be confirmed with ABG)	PaO2 <34, SaO2 <70% "severe" if: • PAO2 ≤ 28, SaO2 ≤ 65% • PH is low • Not responding to maneuvers	• **Always**: check CXR & Hgb, transiently increase FiO2, evaluate ventilator with respiratory therapist • **Consider** vasoactive medications, increased MAP goal, shunt imaging (echo vs cath) • If "severe", call to surgeon*
		PaO2 >45, SaO2 > 85%	• **Always**: wean FiO2 • **Consider** weaning vasoactive infusions vs. adding milrinone &/or TTE (arch imaging)
Blood Pressure	**Record right arm BP and simultaneous umbilical artery line BP within 2 hours after arrival to CICU** MAP goal 40-50 Lower MAP goal can be appropriate depending on gestational age Higher MAP goal can be appropriate depending on oxygenation/end-organ needs	MAP > 50	• If arm hypertension, check leg blood pressure and consider TTE to assess aortic arch repair • **Consider** starting or increasing milrinone; weaning the non-milrinone vasoactive medications
		MAP < lower limit May be permissible if O2 delivery is adequate Frequent calcium boluses	• **Always**: evaluate perfusion, urine output, chest tube output, rhythm, calcium level and acidosis • **Consider**: vasoactive infusions (see below), lowering milrinone dose, TTE to check function, effusion

Guideline for Post-Operative Days 0-2 after Norwood Operation (continued, p. 2 of 3)			
Monitoring	**Guide**	**Worrisome Sign/Trend**	**Considerations**
RA (CVP) pressure	Goal RAp 4-9 If abnormality, check: Waveform (re-zero line) Infusing status Blood return	RAp < 4	• Consider volume infusion (especially if tachycardia or hypotension) • Consider TTE (agitated saline injection to confirm RA line position)
		RAp > 9	• Always: check chest tube(s) patency, CXR • TTE (function, effusion, avvr, arch repair, agitated saline) • If hemodynamically significant, call to surgeon*
Chest tube output	Goal < 3 cc/kg/hr (Of note laboratory assessment of significant bleeding includes: CBC, PT, PTT INR and fibrinogen	>3 cc/kg/hr Severe if >10cc/kg/hr or not responding to blood products	• CXR • If MAP> 50, see "Blood Pressure" above • Consider coagulopathy and thrombocytopenia • Consider ordering vs. giving empiric blood products • If severe, call to surgeon & anesthesia* • Consider Novo7, protamine (with surgeon input)
		Sudden drop in output	• Check chest tube patency • If hemodynamic significant: CXR, consider TTE and call to surgeon*
Arrhythmia management	**ECG within the first 12 hours post-op**	Arrhythmia	• Always: repeat ECG • Consider Electrophysiology consultation, weaning vasoactive infusions if adrenergic driven • Discussion with CICU attending prior to starting antiarrhythmic

Guideline for Post-Operative Days 0-2 after Norwood Operation (continued, p. 3 of 3)			
Monitoring	**Guide**	**Worrisome Sign/Trend**	**Considerations**
Vasoactive infusions	General starting doses: Dopamine 3 mcg/kg/min Epinephrine 0.02 mcg/kg/min	VIS = Dopa + Epi x 100 VIS increasing by 2 VIS >5 Dopamine > 5 Epinephrine > 0.05	• Always: CXR, make sure line is working • Call to surgeon* • TTE (function, fluid, AVVR, arch repair, agitated saline injection to assess line position)
Renal function/ Diuretics	**Start Lasix when UOP is < 1c/kg/hr** Starting dose of furosemide: Intermittent: 1mg/kg/dose Q 6 hr Infusion: 0.1 mg/kg/hr	No response to diuretic Rising Creatinine Clinical fluid overload	• Always: troubleshoot Foley catheter • Check BMP • If no UOP despite escalating diuretics, consider renal U/S +/- nephrology consultation
Ventilator management	Goal TV 10-12 cc/kg/hr Initial Peep 3-5 RR 20-30	Refractory respiratory acidosis Need RR>30 PIP >30 or sudden increase	• Always: suction ETT, CXR • Troubleshoot ventilator with respiratory therapist
Analgesia & Sedation	**All patients should receive Tylenol IV (unless clinical contraindications)** **Refer to Extubation Readiness Guideline.** *If extubation is planned **24-48 hours*** after arrival, preferred strategy: Analgesia: Ketamine infusion (0.15 mg/kg/hr) Sedation: Dexmedetomidine (0.2 mcg/kg/hr) *If extubation is planned **after 48 hours***, follow CICU sedation pathway. Consider neuromuscular blockade for unstable patients	More than 3 fentanyl doses administered in 4 hours Escalating ketamine or fentanyl infusion	• Increase Dexmedetomidine or ketamine infusions • Consider increasing Milrinone or giving Fentanyl prn if hypertension with intent to preserve extubation readiness by 1st post-operative morning • To avoid peri-extubation narcotics, consider leaving infusions on through extubation or turning off at the time of extubation.

***If discussion with surgeon includes consideration of intervention (eg. re-exploration, cath, ECMO)**: 1) Call **anesthesia**; 2) **Call blood bank** and order blood products for intervention/ECMO; 3) **Order procedure request** (surgical or cath) OR start **ECMO order set** according to patient weight.

Review the following CHOP Pathways for additional guidance:

Nutrition Pathway for Neonates after Surgery for Congenital Heart Disease

Inpatient Pathway for the Evaluation/Treatment of Fetus or Newborn with Single Ventricle

QI team will schedule a post-operarive inter-disciplinary debrief session. Please contact QI team leads with any questions or suggestions (contact information included)

Abbreviations

AVVR	atrioventricular valve regurgitation
Cath	cardiac catheterization
CICU	cardiac intensive care unit
CPB	cardiopulmonary bypass
CBC	complete blood count
CVP	central venous pressure
CXR	chest x-ray
ECG	electrocardiogram
ECMO	extracorporeal membrane oxygenation
ETT	endotracheal tube
FFP	fresh frozen plasma
Hgb	hemoglobin
Hct	hematocrit
iNO	inhaled Nitric Oxide
MPA	mean arterial pressure
MUF	modified ultrafiltration
Novo 7	Coagulation Factor VIIa (Recombinant)
NP	nurse practitioner
OR	operating room
PRBC	packed red blood cells
PT/INR	prothrombin time/ international normalized ratio
PTT	partial thromboplastin time
RAp	right atrial pressure
TEE	transesophageal echocardiogram
TTE	transthoracic echocardiogram
UOP	urine output
VIS	vasoactive infusion score