Winnipeg Regional Health Authority / Office régional de la santé de Winnipeg Caring for Health / À l'écoute de notre santé **NEONATAL CLINICAL PRACTICE GUIDELINE**	**Title:** **Brain Oxygen Monitoring in Newborns Using Near Infrared Spectroscopy (NIRS)**	
	Approval Date: June 2016	**Pages:** *1 of 9*
	Approved by: Neonatal Patient Care Teams, HSC & SBH Child Health Standards Committee	**Supercedes:** **none**

1.0 PURPOSE AND INTENT

1.1 Provide the clinical indications, clinical assessment tools and guidelines for use of near infrared spectroscopy (NIRS) for brain saturation monitoring in neonates within the neonatal units in the WRHA.

Note: All recommendations are approximate guidelines only and practitioners must take in to account individual patient characteristics and situation. Concerns regarding appropriate treatment must be discussed with the attending neonatologist.

2.0 PRACTICE OUTCOME

2.1 Optimize brain oxygen homeostasis in neonates on oxygen therapy. To decrease the incidence of both hyperoxia and hypoxemia especially in premature infants at risk of chronic lung diseases. To decrease the overall potential effect of disturbed oxygen hemostasis in neonates.

3.0 DEFINITIONS

3.1 **Near infrared spectroscopy (NIRS):** Continuous direct measurement of brain oxygenation through cerebral oximetry. Cerebral oxygenation is expressed as a percentage (from 0% to 100%) and represents the hemoglobin–oxygen saturation in all sections of the vasculature and therefore is 'venous weighted'.

3.2 **Tissue oxygenation index (TOI)**: It is also called regional oxygen saturation measured by NIRS and reflects venous oxygen saturation. Normal range as recommended in the literature is between 55% to 85%.

3.3 **Oxygen consumption** = SaO_2 – TOI. It is normally between 15%-33%.

4.0 INDICATIONS

4.1 Infants with cardiovascular compromise as a component of integrated evaluation of neonatal hemodynamics (IENH) (See IENH Clinical Practice Guideline)

4.2 Infants on oxygen therapy >30% until weaning (TNE may be also considered to R/O pulmonary hypertension). See Appendix A for algorithm for management.

4.3 Infants on oxygen during oxygen reduction (tolerance) test.

5.0 GUIDELINES

5.1 Neonatologist or designate - Order brain oxygen monitoring with NIRS based on the indications above. It may also be ordered by a Neonatologist performing IENH.

5.2 Registered Respiratory Therapist (RRT) - Integrate the results from NIRS with the oxygen histogram from the oximeter and report the results daily during patient rounds. Record the oxygen saturation histograms on the record found in Appendix C. Indicate on the form when any changes in management or new interventions were initiated in order to assess their effect on the results. Use the number for the interventions found on the list in Appendix D.

5.3 Nurse - Record NIRS values at least hourly on the patient data record at the same time as corresponding oxygen saturation level. See Appendix E for specific information for application and management.

5.4 Maintain the sensor according to the following"

5.4.1 Use only the sensor specifically manufactured for the brand of monitor.

5.4.2 Use the sensor for a single patient

5.4.3 Apply the sensor to any part of the head avoiding the fontanel. Apply on bare skin, or shave any hair (using a safety razor) under the sensor as hair absorbs the light and skews the results

5.4.4 Do not use adhesive. Use a soft cloth or gauze wrap to hold the sensor in place. Move the sensor to a different site if the readings are not consistent with the clinical assessment. Reposition the sensor every 3-4 hours and inspect the skin for redness and integrity.

5.5 The Attending Neonatologist, Neonatologist performing IENH and the RRT - Discuss the results of the monitoring to make decisions about further interventions, incorporating assessment of cardiovascular, respiratory and blood carrying capacity, to avoid both hypoxia and hyperoxia (normal range 55% to 85%).

5.6 **When TOI <55% (risk of hypoxemia): (See Appendix B for algorithm)**

5.6.1 Consider first iatrogenic causes. Try to decrease mean airway pressure (as high MAP may compromise venous return). If PCO_2 below the normal range or low, even in the normal range, consider decreasing minute ventilation

5.6.2 Assess cardiovascular status: Blood pressure below the normal range, even in the normal range with other clinical signs of cardiovascular compromise (Lactate >2.8 mmol/l, capillary return >3 s, or Urine output <1 ml/kg/h)
Low BP =Mean B/P below 3rd centile for corrected gestational age (CGA).
See Appendix E for normal blood pressure values.

5.6.3 Consider:

- Fluid bolus (normal saline)
- Dopamine 5mcg/kg/min (if Diastolic below 3rd centile for CGA or both systolic and diastolic are low)
- Dobutamine 5mcg/kg/min (if systolic BP below 3rd centile for CGA)

5.6.4 If no response, consider IENH consultation to assess for:

- Hyper dynamic heart with low SVR: consider vasopressor infusion.
- Poor systolic myocardial performance: consider inotrope infusion.
- PDA: consider medical treatment
- Exclude congenital heart disease

5.6.5 Assess oxygen transport: Hemoglobin potentially not adequate for optimal oxygen carrying capacity and no other causes for low TOI. Consider red blood cell transfusion.

5.6.6 Assess respiratory status: SaO_2 below the normal range or low, even in the normal range, consider:

- Increase FiO_2 (attention: be careful not to exceed the upper target threshold of SaO_2)
- Increase mean airway pressure (optimize FRC)
- Consider other causes of hypoxemia (pulmonary hypertension, limited diffusion, V/Q mismatch)

5.7 **When TOI >85% (risk of hyperoxia):**

5.7.1 Assess respiratory status.
SaO_2 above the normal range or high, even in the normal range, consider:
- Decreasing FiO_2
- Decreasing mean airway pressure

PCO_2 above the normal range or high, consider:
- Increase minute ventilation

5.7.2 Assess blood glucose level:
Blood glucose <2.6 mmol/l, consider:
- Increase glucose intake

5.8 Allow a 60 minutes assessment period before considering any new intervention when TOI is lower than the normal range.

6.0 REFERENCES

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6.2 Greisen, G., Leung, T., & Wolf, M. (2011). Has the time come to use near-infrared spectroscopy as a routine clinical tool in preterm infants undergoing intensive care? Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 369, 4440–4451.

6.3 Hyttel-Sorensen, S., Pellicer, a., Alderliesten, T., Austin, T., van Bel, F., Benders, M., Greisen, G. (2015). Cerebral near infrared spectroscopy oximetry in extremely preterm infants: phase II randomised clinical trial. Bmj, 350(January), g7635–g7635.

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6.5 Pellicer, A., Greisen, G., Benders, M., Claris, O., Dempsey, E., Fumagalli, M., … Austin, T. (2013). The SafeBoosC phase II randomised clinical trial: A treatment guideline for targeted near-infrared-derived cerebral tissue oxygenation versus standard treatment in extremely preterm infants. Neonatology, 104(3), 171–178.

6.6 Saugstad, O. D. (2012). Hyperoxia in the term newborn: more evidence is still needed for optimal oxygen therapy. Acta Paediatrica, 101, 34–38.

6.7 Zubrow, A.B., Hulman, S., Kushner, H. & Falkner, B. (1995). Determinants of blood pressure in infants admitted to neonatal intensive care units: A prospective multicenter study. Journal of Perinatology, 15(6) , 470-479.

7.0 PRIMARY AUTHORS

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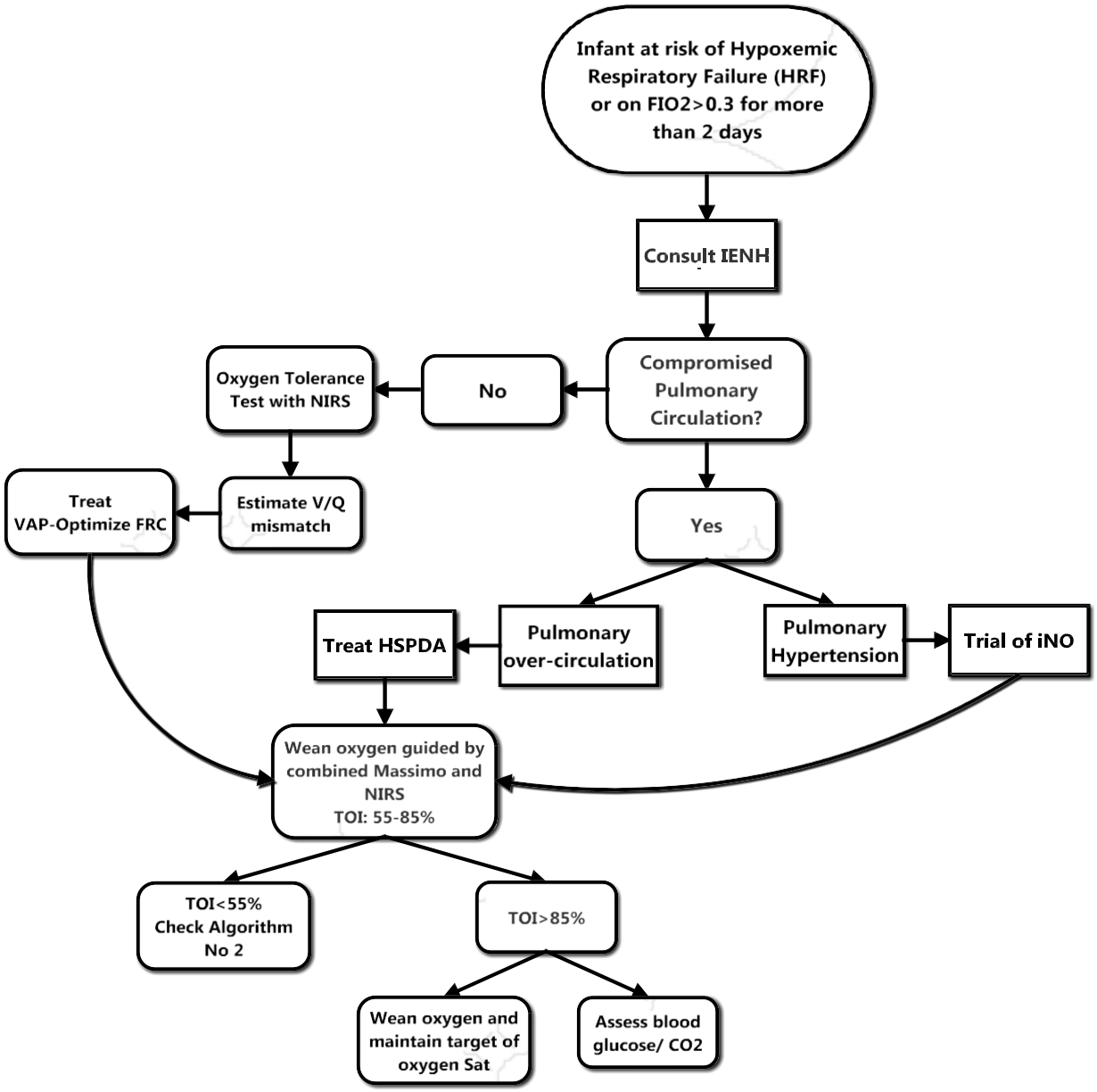
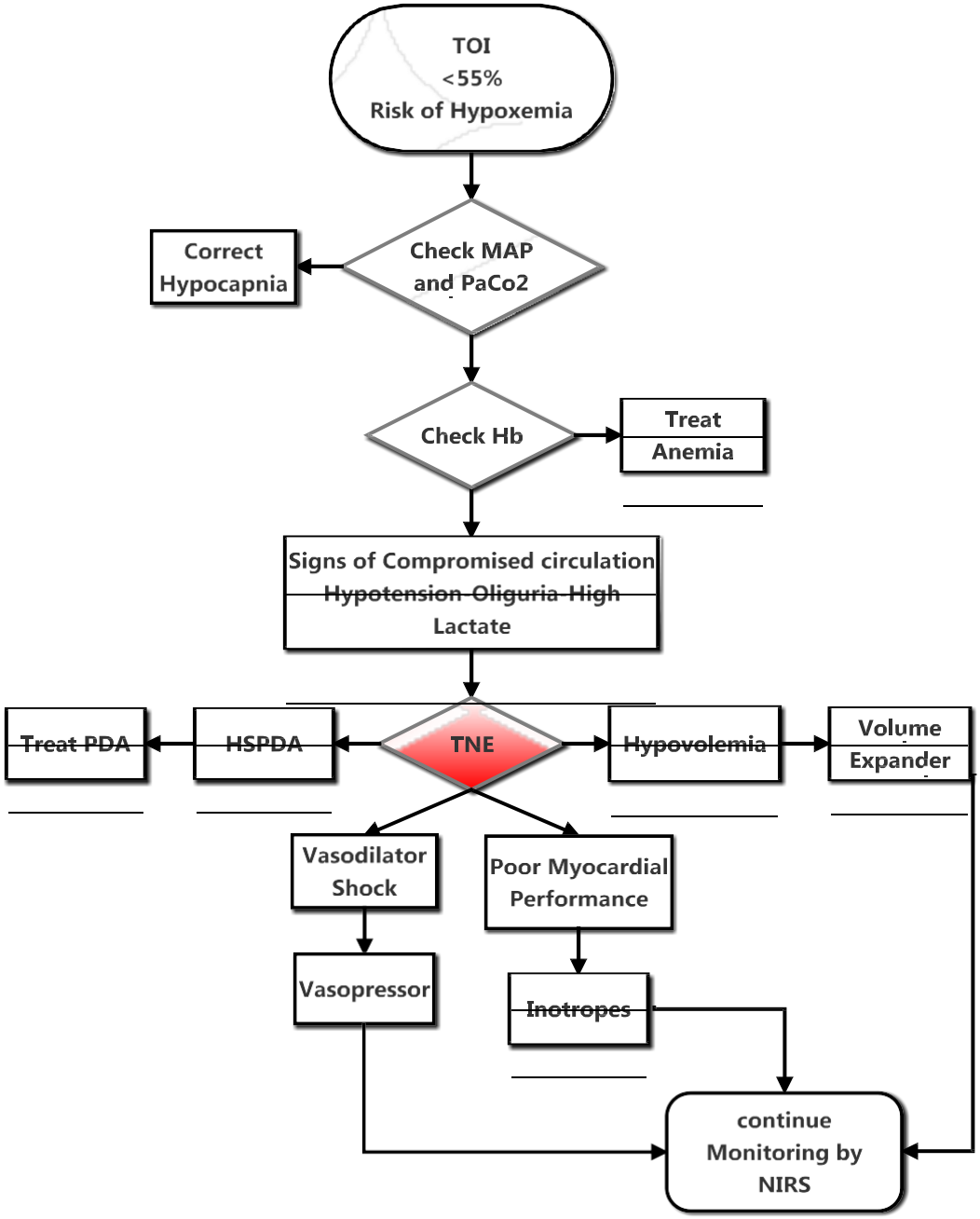
APPENDIX A

Algorithm #1: Management of Infants at Risk of Hypoxemic Respiratory Failure (HRF) Using Brain Oxygen Monitoring



APPENDIX B

Algorithm #2: Management of Infants with Low TOI



APPENDIX C


OXYGEN SATURATION HISTOGRAM
Reporting Starts From:
To:
NOTES
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Week 1
Week 2
Percent of time with SaO2 above 90%
Percent of time with SaO2 below 80%
FIO2
DRAFT
HEALTH RECORD FILING - TO BE DETERMINED

APPENDIX D
Intervention Codes

Mark the number of the intervention on the Daily Oxygen Saturation Histogram (HSC Form NA01764)

Code #	Intervention	Note
1	Decrease in VG	From 1 to 6: Weaning interventions
2	Decrease mean airway pressure or PEEP	
3	Discontinue CPAP	
4	Downgrade from HFV to conventional	7-17 : Graded supportive interventions
5	Extubation	
6	Accept oxygen saturation (85-90%) and monitor brain by NIRS	
7	Increase in VG	
8	Increase mean airway pressure or PEEP	
9	PDA medical treatment	
10	Antibiotics for chest infection	
11	Inhaled nitric oxide	
12	Start CPAP	
13	Intubation	
14	Steroids for BPD	
15	Upgrade from conventional to HFV	
16	Cardiovascular support (vasopressor or inotropes)	
17	PDA surgical treatment	

Adjusted on July 4th 2018 by Yasser Elsayed and Karen Belen
Blood pressure ranges for the first day of life:

Gest age	Systolic			Diastolic			Mean(derived)			Pulse Pressure
weeks	Highest (95%)	Mean (50%)	Lowest (5%)	Highest (95%)	Mean (50%)	Lowest (5%)	Highest (95%)	Mean (50%)	Lowest (5%)	Mean (50%)
22	55	39	22	31	23	14	39	28	17	16
23	56	40	23	32	24	15	40	29	18	16
24	57	42	25	33	25	16	41	31	19	17
25	58	43	26	34	26	17	42	32	20	17
26	60	44	27	35	27	18	43	33	21	17
27	61	45	29	36	28	19	44	34	22	17
28	63	47	31	37	29	20	46	35	24	18
29	64	48	33	38	30	21	47	36	25	18
30	66	50	35	39	31	22	48	37	26	19
31	68	51	36	40	32	23	49	38	27	19
32	69	52	37	41	33	24	50	39	28	19
33	70	53	38	42	34	25	51	40	29	19
34	71	55	40	43	35	26	52	42	31	20
35	73	57	41	44	36	27	54	43	32	21
36	75	59	42	45	37	28	55	44	33	22
37	76	60	44	46	38	29	56	45	34	22
38	77	61	46	47	39	30	57	46	35	22
39	79	62	47	48	40	31	58	47	36	22
40	81	64	48	49	41	32	60	49	37	23
41	82	65	50	50	42	33	61	50	39	23
42	84	67	51	51	43	34	62	51	40	24

Blood pressure ranges for Post – menstrual age (in weeks)

age	systolic			Diastolic			Mean(derived)			Pulse Pressure
weeks	Highest (95%)	Mean (50%)	Lowest (5%)	Highest (95%)	Mean (50%)	Lowest (5%)	Highest (95%)	Mean (50%)	Lowest (5%)	Mean (50%)
24	68	49	33	46	29	14	53	36	20	20
25	69	51	36	47	30	15	54	37	22	21
26	70	52	38	48	31	17	55	38	24	21
27	71	54	40	49	32	18	56	39	25	21
28	72	55	41	50	33	19	57	40	26	21
29	73	56	42	51	34	20	58	41	27	21
30	75	59	43	52	35	21	60	43	28	23
31	78	61	46	53	36	22	61	44	30	24
32	80	62	48	54	37	23	63	45	31	25
33	81	63	50	55	38	24	64	46	33	25
34	83	66	51	56	39	25	65	48	34	26
35	84	69	52	57	40	26	66	50	35	27
36	87	71	55	58	41	27	68	51	36	29
37	89	72	57	59	42	28	69	52	38	30
38	90	75	59	60	43	29	70	54	39	30
39	91	78	60	60	44	30	70	55	40	30
40	92	80	61	61	45	30	71	56	40	31
41	93	81	62	62	46	31	72	58	41	31
42	95	82	63	63	47	32	74	59	42	32
43	97	83	65	64	48	33	75	60	44	33
44	98	86	67	65	49	34	76	61	45	33
45	100	88	69	66	50	35	77	63	46	34
46	102	89	71	66	51	36	78	64	48	36

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Derived from Zubrow, A.B., Hulman, S., Kushner, H. & Falkner, B. (1995). Determinants of blood pressure in infants admitted to neonatal intensive care units: A prospective multicenter study. Journal of Perinatology, 15(6), 470-479