NEONATAL ANESTHESIA PROTOCOL

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Preoperative Evaluation:

- Indications for the operation and a description of the condition and the course and treatment of the illness
- Congenital anomalies and heart murmurs (follow up on the last echocardiogram, EKG and NICU Attending Communication)
- Complications of prematurity, such as
  1. GA -Gestational age (wks); PCA- Postconceptual age (GA + wks since birth); or history of apnea and bradycardia (A & B)
  2. BPD and CLD
     - History of ventilator management/ airway management (receding chin)
     - Vent. settings, if intubated
     - ETT size and mark at the lip and that it is well secured
     - Lung exam
     - CXR
     - CBG/ABG
     - Last nebs
  3. Previous surgical interventions and review anesthesia records to check airway and other issues
  4. CNS: intraventricular hemorrhage, developmental delay
  5. CVS: check VS (BP, HR, RR, Temp, sPO2, FIO2)/ echocardiogram/cardiology note
  6. GERD
  7. Venous, arterial access
  8. Medication list (last given)
  9. Labs and availability of blood if needed
  10. NPO guideline
- Anesthesia Consent: Meeting the parents or calling them (Attending involved)
- Communication with NICU fellow or Attending
  - (Fellow available 24/7 - phone # 444-5815)

Preparation and Set-up for a Neonatal case:

- Check anesthesia machine per routine
- Suction (ETT size suction available – 6-8F for ETT; 10F or yankauer for O/P)
- Pediatric Breathing circuit (check automatic and manual ventilation).
- Neonatal BP cable and cuff (set BP to neonatal mode)
- Spirometry and monitor set up to pediatric
- Ventilator settings (PCV)
- Sevoflurane vaporizer
- Routine monitors following standard of care with precordial stethoscope (BP on upper arm unless UA not available)

Temperature Maintenance:

- Underbody Bair-hugger
- Fluid warmer for blood and products (volume measured)
- Overhead Lights
  - Monitor temperature (esophageal or rectal) for all cases (document the site and warming technique used)

Medications:

- Propofol (10 mg/ml) – 1 ml x 3
- Succinylcholine (20 mg/ml) – 1 ml
- Atropine (0.4 mg/ml) 1ml + 2 ml of Succinylcholine (20 mg/ml)- 3 ml
- Atropine (0.4 mg/ml) – 1 ml
- Muscle relaxant of choice – 1 ml
  - Use Atracurium or Cisatracurium if planning to extubate
  - Rocuronium, Vecuronium or Pancuronium if postoperative ventilation planned
- Fentanyl (50 mcg/ml) – 1ml
- Fentanyl (1 mcg/ml) in a 10 ml syringe (for CI) in a syringe pump
- Caudal block: 0.25% bupivacaine with epinephrine 1:200,000 or 0.2% ropivacaine; Dose 0.5-1 ml/kg; 23 G, 1 inch needle
- Caffeine Citrate (20 mg/ml) – 3ml vial to prevent A & B if deemed clinically necessary
  - Unit dose is 10 mg/kg (5-20 mg/kg) given slowly over 10-15 min.
- Have following drugs available in **unopened boxes**:
  - Calcium Chloride (100 mg/ml)
  - Epinephrine (100 mcg/ml – 1:10,000 solution)
  - Neonatal Sodium Bicarbonate 4..2% - (0.5 mEq/ml)
- In addition: Set up following drugs for high risk cases either by ASA status, type of surgery or when significant blood loss is expected: Prepare unit doses of sodium bicarbonate and calcium chloride in advance.
  - Calcium Chloride (100 mg/ml) - 1 or 3 ml syringe x 3
    - Unit dose is 20 mg/kg
  - Epinephrine (10 mcg/ml- dilute 1 ml of Epinephrine 100mcg/ml – 1:10,000 in 9 ml of NS) – 1ml syringe x 3
    - Unit dose for hypotension is 1-10 mcg/kg
  - Epinephrine (100 mcg/ml – 1:10,000 solution)
    - CPR dose is 10 mcg/kg (0.1 ml/kg of 1:10,000 epinephrine solution)
  - Neonatal sodium bicarbonate – (0.5 mEq/ml) – 5 ml x 3;
    - Unit dose of is 1-2 mEq/kg
  - Dopamine infusion (200 mg/250ml D5W – 800 mcg/ml)
    - Dose 3-20 mcg/kg/min

- Epinephrine (2 mg/100 ml D5W – 20 mcg/ml) Dose 0.05-2 mcg/kg/min

Airway:

- Appropriate size C-MAC, Miller and MAC laryngoscopes; (size 0 usually for premies and full term newborns depending upon the weight)
- ETT/s (uncuffed ETT), oral airway/s; the smallest cuffed ETT available are size 3.0 which is appropriate for a full term newborn or an expremie more than 3 kg or gestational age 35-40 weeks.
- Investigators have recommended age-appropriate sizes for Microcuff® TTs in infants and children. For full-term neonates (>3 kg) to 6 months of age, they recommend a 3.0 mm ID Microcuff® TT, and for infants 6–18 months, a 3.5 mm ID TT. Guidelines recommend 3.5 mm ID uncuffed TT for neonates and a 4.0 mm ID TT for 1 yr olds.
- White adapter for CO2 monitoring

IV Fluids:

- Maintenance IVF on syringe pump with D5W at 1 x normal maintenance rate **or** D10% **or** TPN at 1/2 the normal maintenance rate
- Set up 1 or 2 sets of remaining fluids (LR) prefilled with 50 ml in the buretrol.; stopcock; peds extension; stopcock; peds blue tipped small extension
- Calculate deficit, maintenance rate, 3rd space loss/hr, EBV and ABL

A-line, CVP as indicated

Blood poducts: In addition, if blood loss is expected:

- 5% albumin (10 ml) x 5 (50 ml 25% albumin in 250cc NS)
- PRBC/FFP as indicated thorough a blood warmer, or in neonatal syringes from the blood bank

Induction and maintenance of anesthesia:

Induction:

- Suction NG/OG tube if present; Place monitors (EKG, BP-UA, sPO2-pre-ductal on right hand, ± A-Line)
- Give a bolus of 10 ml/kg of LR prior to induction of anesthesia
- Preoxygenation, IV for modified RSI
- For modified RSI, IV versed (0.1-0.2 mg/kg), or propofol (1-3 mg/kg) or ketamine (2-3 mg/kg) + IV Succinylcholine (2mg/kg) + Atropine (20-30 mcg/kg), crocoid pressure, low pressure ventilation and intubate
- Routine induction, IV induction as above or slow and low dose inhalation induction with 100% oxygen and sevoflurane preferable (if

not full stomach) with slow control of the airway and assisted ventilation prior to administration of muscle relaxant
- +/- Atropine 20 mcg/kg or minimum of 0.1 mg whichever is greater
- +/- IV propofol 1 mg/kg increments
- +/- IV fentanyl 0.5-2 mcg/kg
- +/- IV versed 0.1-0.2 mg/kg

Airway:
- Confirm Uncuffed ETT size
  - ETT internal diameter in millimetres can be calculated as (gestational age in weeks divided by 10):
    - 2.5 mm ETT for neonates less than 1 kg
    - 3.0 mm ETT for neonates 1–2 kg
    - 3.5 mm ETT for neonates 2–3 kg
    - 3.5 – 4.0 mm ETT for neonates greater than 3 kg
  - Approximate ETT insertion depth from middle of upper lip can be calculated as (weight in kg + 6 cm)
- Placement by DL – (confirm by markings on ETT and auscultation of bilateral breath sounds)
- Continue ventilation
- Attending anesthesiologist to reconfirm ETT placement by repeat laryngoscopy, confirmation of ETT markings and auscultation of bilateral breath sounds
- Note the depth mark at the lips and secure carefully at that mark; perform leak test
- Micro-Cuffed ETT is used selectively when indicated, at the discretion of the attending anesthesiologist.

IV Fluids:
- See chart and reference for normal SBP and DBP in premies below;
  - Mean BP (mm Hg) in premies is usually PGA in weeks.
  - Depending on PGA (23-50 wks), 20% deviation of mean BP can be as little as a mean change of 4-10 mm Hg which is a substantial change in a neonate
  - Start dopamine early if BP is unresponsive to fluids and blood; Decreased contractile element in neonatal myocardium and blunting of baroreceptor reflexes
- Maintenance IVF on pump with 5% dextrose continuously at normal maintenance rate (D10% and TPN at half the normal maintenance rate)
- Remaining fluids (LR) prefilled with 50 ml in the buretrol. with careful documentation of crystalloids, colloids and blood (in milliliters)

Maintenance of Anesthesia:

- Pain Control: See reference and dosing table below
  - Premies and ex-premies are prone for having A & B episodes after receiving sedatives, narcotics and anesthetics. Vulnerable period is up to 46 weeks PCA, but can extend up to 60 weeks. Therefore, plan on using local, regional, caudal, and short acting sedatives and hypnotics such as propofol to supplement inhalational anesthesia. No intraoperative narcotic if planning to extubate
  - Preoperative planning and calculation as per surgical needs, surgery type, use of local anesthesia by the surgeon, use of regional blocks, bolus versus CI pump administration.
  - Increase fentanyl dose for narcotic tolerant neonates.
  - For "fast-tracking" and early extubation following major surgery, total fentanyl doses are limited to 10-15 mcg/kg.
- FIO2, Sedation, Hypnosis and Amnesia:
  - Air/O2 mixture to maintain sPO2 (pre-ductal on right hand) at 92-97%
  - Versed bolus or CI
  - Low dose inhalation agent
- Muscle relaxation:
  - Atracurium or Cisatracurium if planning to extubate
  - Rocuronium, Vecuronium or Pancuronium if postoperative ventilation planned
- Reverse muscle relaxation with Neostigmine and Glycopyrrolate if planning to extubate

Transition from OR to NICU:

- Anesthesia provider to call NICU nurse for report
- For neonates who will remain intubated post-op, give additional versed (0.1-0.2 mg/kg), fentanyl (1-4 mcg/kg) and muscle relaxant dose prior to transfer from OR bed to the incubator.
- Be prepared to give additional versed and fentanyl doses in NICU as indicated prior to hand-off to NICU staff.

- Every effort will be made for Hand-off reporting and communication between NICU fellow or Attending and Anesthesia attending
- Careful and thorough documentation of post-op vital signs (BP, HR, RR, Temp, LOC), and ventilator settings on the anesthesia records

Intraoperative narcotic requirements: Fentanyl

Type of Surgery	Type of Surgery: For e.g.	Initial Bolus Dose – 1st hour	Maintenance Dose: Bolus or CI
Mild	Hernia, pyloromyotomy, GU, VP shunt, ENT, Plastic, Meningomyelocele repair	0.5-2 mcg/kg	0.5-2 mcg/kg/hr
Moderate	Colostomy, pull –through, etc	2-10 mcg/kg	1-2 mcg/kg/hr
Severe	Major Abdominal, Thoracic	2-20 mcg/kg	1-4 mcg/kg/hr

Fentanyl Dosage:

Doses should be titrated to appropriate effects; wide range of doses exist, dependent upon desired degree of analgesia/anesthesia, clinical environment, patient's status, and presence of opioid tolerance.

- Neonates and younger Infants:
  ----Sedation/analgesia: Slow IV push: 1 to 4 mcg/kg/dose; may repeat every 2 to 4 hours
  ----Continuous sedation/analgesia: Initial IV bolus: 1 to 2 mcg/kg, then 0.5 to 1 mcg/kg/hour; titrate upward
  ----Mean required dose: Neonates with gestational age less than 34 weeks: 0.64 mcg/kg/hour; neonates with gestational age greater than or equal to 34 weeks: 0.75 mcg/kg/hour
  ----Continuous sedation/analgesia during extracorporeal membrane oxygenation (ECMO): Initial IV bolus: 5 to 10 mcg/kg slow IV push over 10 minutes, then 1 to 5 mcg/kg/hour; titrate upward; tolerance may develop; higher doses (up to 20 mcg/kg/hour) may be needed by day 6 of ECMO.

- Adjunct to general anesthesia: Slow IV:
  ----Low dose: 0.5 to 2 mcg/kg/dose depending on the indication
  ----Moderate dose: Initial: 2 to 20 mcg/kg/dose; Maintenance (bolus or infusion): 1 to 2 mcg/kg/hour. Discontinuing fentanyl infusion 30 to 60 minutes prior to the end of surgery will usually allow adequate ventilation upon emergence from anesthesia. For "fast-tracking" and early extubation following major surgery, total fentanyl doses are limited to 10 to 15 mcg/kg.
  ----High dose: 20 to 50 mcg/kg/dose; Note: High dose fentanyl as an adjunct to general anesthesia is rarely used, but is still described in the manufacturer label.

Neonatal Blood Pressures obtained by Dinamap Method

(BIRTH WEIGHT 600-1750 G)1

/> Day	600-999 g		1000-1249 g	
	S (± 2SD)	D (± 2SD)	S (± 2SD)	D (± 2SD)
1	37.9 (17.4)	23.2 (10.3)	44 (22.8)	22.5 (13.5)
3	44.9 (15.7)	30.6 (12.3)	48 (15.4)	36.5 (9.6)
7	50 (14.8)	30.4 (12.4)	57 (14)	42.5 (16.5)
14	50.2 (14.8)	37.4 (12)	53 (30)	
28	61 (23.5)	45.8 (27.4)	57 (30)	
/> Day	**1250-1499 g**		**1500-1750 g**	
	S (± 2SD)	**D (± 2SD)**	**S (± 2SD)**	**D (± 2SD)**
1	48 (18)	27 (12.4)	47 (15.8)	26 (15.6)
3	59 (21.1)	40 (13.7)	51 (18.2)	35 (10)
7	68 (14.8)	40 (11.3)	66 (23)	41 (24)
14	64 (21.2)	36 (24.2)	76 (34.8)	42 (20.3)
28	69 (31.4)	44 (26.2)	73 (5.6)	50 (9.9)
[1]Blood pressure was obtained by the Dinamap method.				
S = systolic; D = diastolic; SD = standard deviation.				
Modified from Ingelfinger JR, Powers L, and Epstein MF, "Blood Pressure Norms in Low-Weight Infants: Birth Through Four Weeks", *Pediatr Res* , 1983, 17:319A.				

Anesthetic management of Surgical Ligation of Patent Ductus Arteriosus at GUH: Sudha A. Ved, MD, FAAP September 26, 2005

Patency of DA is common in very premature infants. Congestive heart failure usually develops in the second week of life. Failure to wean from the ventilator and recurrence of respiratory distress, episodic apneas and unexplained rise in CO2 are common. There is excessive pulmonary blood flow because of left-to-right shunt between aorta and pulmonary artery through the DA leading to left atrial and left ventricular overload and pulmonary venous hypertension, which cause pulmonary edema and right ventricular failure. Within several weeks, cardiomegaly, bounding pulses, a hyperdynamic precordium, and a continuous murmur develop. Myocardial and cerebral blood flow are reduced and there is aortic diastolic hypotension to other essential organs including the gut and lower extremities predisposing the infant to necrotizing enterocolitis and intraventricular

hemorrhage. Blood pressure, especially diastolic blood pressure is lower in lower extremities compared to right upper extremity.

Conservative medical management for all groups include the use of mechanical ventilation and supplemental oxygenation when needed, diuretics, indomethacin and transfusion to maintain red cell mass, and fluid restriction. Failures of these measures or infants who do not qualify for indomethacin therapy are surgical candidates for closure of PDA. These cases are done in the NICU to minimize hazards associated with transport to the operating room.

ANESTHETIC MANAGEMENT:

- Surgery is done on an infant warmer in the NICU, however the warming overhead is turned sideways, out of the way of the surgeon. Surgery is done via a left thoracotomy incision.
- NICU will provide ventilatory support, two pulse oximeters, two NIBP's (one on right arm and one on lower extremity), and $\pm$ A-line.
- Ask NICU to send for a split syringe pack of PRBC before start of surgery
- Anesthesia to bring a Propac with capnography, a pediatric anesthesia cart and an infant whole body Bair Hugger blanket with the unit to warm.
- Set up airway, ET tubes with stylettes ready to go and IV equipment (50 ml LR in a buretrol) as usual with small 6-8F suction catheters, 9F rectal temperature probe and 9F esophageal stethoscopes available. Surgeon will ask you to listen for loss of murmur after ligation of the PDA. Set up the Bair Hugger blanket below the infant
- Make sure you have a properly functioning IV present before start of surgery. Set up several 3-5 ml flush syringes.
- Set up 1ml syringes of versed, fentanyl, atropine, and pancuronium or vecuronium, succinylcholine and 10mcg/ml of epinephrine. Have available 5% albumin, neonatal bicarbonate, epinephrine Bristoject 1:10,000, and Calcium Chloride.
- Anesthetic management consists of versed 0.1-0.5 mg/kg, fentanyl 10-15 mcg/kg and 0.1-0.2 mg/kg of pancuronium or vecuronium. Give a bolus of 10 ml/kg of LR prior to induction of anesthesia. KVO fluid line and give boluses of LR. 5% albumin or PRBC as needed. Ventilatory management consists of increasing FIO2 to 100% and/or increasing mean and PIP's as needed during manipulation of the lung.

December 03, 2014