Fluids management and transfusion therapy in pediatrics

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Ref: A Practice of Anesthesia for Infants and Children, Cote, Ch 11
The Pediatric Anesthesia Handbook,Bell,Kain, Hughes ,Ch 4
Anesthesia for Infants and Children, Smith ,Ch 4

Goals of Fluids Therapy

- To maintain hydration
- To compensate for fluid and El.lites deficit (NPO, Pt's disease)
- To replace ongoing losses (third space insensible losses, surgical bleeding, UO)
- To compensate for anesthetic effects on vascular volume (↓ PVR, myocardial depression, blunted baroreceptor reflex mechanism => relative hypovolemia

Body fluids compartments

	Infant (preemie)	Child	Adult
Total body water (TBW)	75% to 85%	70%	55% to 60%
Extracellular fluid (ECF)	40%	30%	20%
Intracellular fluid (ICF)	35%	40%	40%

Very premature, low birth wt infants (~750 gm,1000 gm,1500 gm) have high fluid requirements (100-150 ml/kg /24 hr at birth and up to 250-300 ml/kg/24 hr up to the end of first week of life), for high insensible fluid losses due to tin permeable, vascularized skin, use of warming lights….(~60 ml/kg/day during first days of life)

Term infants DOL#1 has lower fluid requirements (70 to 80 ml/kg/24 hr) and gradually increase during first week of life as kidney start to concentrate and diurese (insensible loss – evaporation is ~ 10 ml/kg/day).

NPO Rules

- **Clear liquids** up to **2** hours pre-op

  (water, apple or grape juice)

- **Brest milk** up to **4** hours pre-op

- **Solid food** up to **6** hours pre-op

  (formula, milk)

Severity of dehydration

Percent of body weight loss	**Signs and symptoms**	Amount of body fluid lost, ml/kg (%)	
		Infants	Children
Mild 1%-5%	History of 12-14 hours of vomiting and diarrhea Dry mucous membranes Decreased urination	50 ml/kg (5%)	30 ml/kg (3%)
Moderate 6% -10%	Skin tenting Sunken eyes Depressed fontanelles Oliguria, Lethargy	100 ml/kg (10%)	60 ml/kg (6%)
Severe 11%-15%	Cardiovascular instability Mottling, Hypotension, Tachycardia Anuria Sensorium change	150 ml/kg (15%)	90 ml/kg (9%)
20%	Comma Shock		

Fluid management

Category	Volume	Type
Maintenance	4 ml/kg/h for 0-10 kg 2 ml/kg/h for 10-20 kg 1 ml/kg/hr for >20 kg	i*sotonic crystalloid* (+ glucose) NS, LR , D 2.5%/LR,D5%/LR, D5%/1/2NS, D10% or TPN
Deficit	No. hours x maintenance Replace ½ in 1st h, 1/4/h x next 2 h	isotonic crystalloid NS, LR
Blood Loss	for 1ml blood loss / 3 ml for 1 ml blood loss / 1ml	isotonic crystalloid blood / products or colloid
Third space	2-10 even 20 ml/kg/h, depending on extent of surgery and vital signs	isotonic crystalloid colloid (LR, NS, 5% Albumin, Hetastarch)

Glucose requirement

Glucose level in infants should be maintained in between

45 and **90** mg /100ml

Glucose infusion requirement is **5 mg/kg/min** in infants

Hypoglycemia (Glu. <40mg/100ml) may cause lethargy, jitteriness, somnolence and irreversible CNS damage.

Hyperglycemia (Glu.>150/100ml) (result of the 'stress response" to surgery and possible glucose-containing solution infusion) in sick neonate increase risks of glucosuria, polyuria, dehydration, wound infection, increased incidence of CNS injury after hypoxic episodes.(avoid hyperglycemia during brain and cardiac surgery)

Patients at risk of hypoglycemia and/or on TPN should continue TPN solution at ½ maintenance rate or replace with glucose 10% at maintenance rate as "piggy-back" (use iv pump) on LR or NS as fluids for operative losses

Children at increased risk for hypoglycemia

Preterm and term infants (hepatic glycogen stores are limited, glyconeogenesis is delayed , high metabolic demand)

Infants of diabetic mothers

Infants small for gestational age

Patients who have been receiving TPN (rebound hypoglycemia could result after sudden withdrawal of TPN)

Patients with chronic debilitating illness

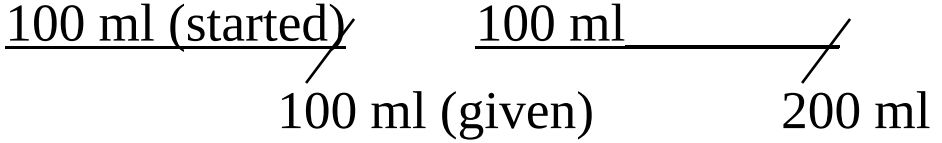
Infants with erythroblastosis fetalis

Blood glucose should be assessed at frequent and regular intervals and corrected

Solution containing glucose or TPN should be continued during surgery with appropriate concentration and rate to keep normoglycemia

IV Fluids Administration Techniques

- **Pediatric IV system**:
  - Bag with IV fluids – buretrol – stopcock- IV extension – T-piece –(for up to about 6 years old)
- **Neonate** – do not fill buretrol with more than 10-15 ml/kg to prevent accidental fluid overload
- **Air free lines** are important (to prevent air embolism in case of PDA, ASD, VSD…
- **Calculate all fluids** requirements and ABL replacement in advance
- **Charting**: LR/NS



Monitoring of Intraoperative Fluids and El –lites Therapy

- **Standard hemodynamic monitoring** (BP,HR, EKG)
- **Urine output** (0.5 - 2 ml/kg/hr)
- specific gravity ~ 1.006 - 1.012,
- osmolality in special situations
- **Serum osmolality**: NL 270 - 280 mOsm/l
- **Glucose level**
- **Invasive monitoring**: A - line, CVP (if rapid/massive blood loss anticipated)

Goals of Transfusion Therapy

- **To increase oxygen - carrying capacity (RBC)**
  (minimal acceptable/preferable hematocrit may be in very broad range, from **Hct 24** in ASA 1 and ASA 2 patient up to **Hct 45** in very premature infants or in patient with cyanotic cardiac anomalies)
- **To improve coagulation (FFP, platelets, cryoprecipitate)**

To preserve hemodynamic stability

Estimates of circulating blood volumes EBW

Adult or obese child	**60-**70	ml/kg
Child > 1 yr.	**70-**75	ml/kg
Infant (3 mo.-1 yr.)	70-**80**	ml/kg
Full term infant	80-**90**	ml/kg
Premature infant	90-**100**	ml/kg

These numbers represent ranges that should serve as a guidelines only..

Physiologic Anemia of Infancy

In term infants lowest level of Hgb (9-11 gm/dl) occurs at 8 to12 wks

In very premature infants even lover Hgb (7-8 gm/dl) occurs at 4 to 8 wks of age

Potential risks of anemia: apnea spells, bradycardia, hypotension, tachycardia, hypoxia.

Etiology (transition from Fetal to adult hemoglobin)

High level of Hgb F ~80% at birth rapidly decreases to 2% at 2 to 3 months (P50=19, poor tissue O_2 delivery in spite of Hct ~45 at birth, **Hgb F** has lower affinity for 2,3-DPG. **Hgb F** has higher affinity for oxygen and low oxygen release to tissue)

Low erythropoietin level at birth gradually increase erythropoiesis with Hgb A , (after 8 to 12 wks) with increase in 2,3-DPG, P50 = 27

Dilutional effects secondary to gradually increasing plasma volume

Limited ability to replace lost RBC - limited iron storage

RBC Transfusion for Pediatric Patients

- Accurately estimate blood loss, calculate allowable blood loss for preferable Hct level
- Consider blood transfusion when **10-15%** of blood volume lost. Hct
- **10 ml/kg of PRBC's** will increase the **Hct by ~ 3%**
- Suitable boluses of PRBC's are ~ 10-15 ml/kg
- Transfuse more than required for anticipated ongoing losses (e.g. Cranyosynostosis)
- Add **CaCl2 10 to20 mg/kg**, for hypocalcaemia with massive transfusion of citrated PRBC, FFP, Plt. Have in mind hypocalcemia if unexplained hypotensin persist during ongoing blood/products transfusion (neonates have limited ability to quickly mobilize calcium and a decreased ability to metabolized citrate)

RBC Transfusion for Pediatric Patients

- Do not dilute PRBC => risk of hypervolemia
- Prefiltered Red cells give by syringe (170 μm filter)
- For neonate recommended frozen deglycerolized RBC or PRBC less than 7 days old blood
- Irradiated - to prevent GVH reaction with leukocytes
- CMV negative - for less than 4 months old
- Split one adult unit as needed (in bag or syringe)

Pretransfusion Testing for Neonate

- **ABO** group and **Rh** type and testing for unexpected antibody should be determined at birth
- No needs for crossmatch during first four months of life (“O” - neg PRBC are appropriate)

FFP

- **FFP** is supernatant of single unit of blood frozen within 6 hours of phlebotomy
- All coagulation factors are present
- Plasma should be ABO compatible but compatibility testing is not required
- FFP contains a relatively large amount of citrate and can cause a transient decrease in ionized calcium and decrease in blood pressure.

FFP Transfusion Indication

- Blood loss > 0.5 to 1.5 blood volume
- PT or PTT patient : control ratio > 1.5 (coagulation factor deficiency , most common is dilitional 2_0 to massive transfusion of PRBC or crystalloids/colloids)
- Clinical evaluation - microvascular bleeding - (“oozing”)
- To reverse effect of Warfarin or Comarin
- Fibrinogen < 75 mg/dl

DOSE: 10-20 ml/kg

Cryoprecipitate

- Cryo is cold-insoluble precipitate from unit of FFP thawed at 1^{o} to 2^{o} C centrifuged and stored at -18^{o} C up to 1 year
- When thawed must be transfused within 4-6 hours via 170 μ filter
- A unit ~ 20 - 40 ml contains 80 -100 units factor VIII activity, 100 - 350 mg of fibrinogen Von Willebrant factor
- No factor V

Cryoprecipitate transfusion Indications

Coagulation Disorder: Congenital and Acquired

- Hemophilia A, Von Willebrant disease
- Massive transfusion
- Clinical bleeding
- Fibrinogen < 80-100 mg/dl

DOSE: 1 unit / 7kg

1 unit / 10 kg ↗ plasma fibrinogen per 50 mg/dl

Platelets

- Centrifugation of 1 unit whole blood = 1 unit platelets
- 1 unit of platelets contains ~ 5.5 x 10^{10} plt in 50-70 ml plasma
- Platelets are stored at 20^{o} to 24^{o} Celsius for up to 5 days with constant gentle agitation
- No need for compatibility testing
- Plt should be filtered dy large-pore filters(>150 um).
- Common dose for pediatric patients is 0.1 to 0.3 U/Kg ;
- this usually produces an increment of 20.000/mm3 to 70.000/mm3

Assessment -possible need for platelets transfusion

- **Chronically sick children** (NEC, prolonged intubations and mechanical ventilation , with chemotherapy, RT…
- **Children with cyanotic cardiac anomalies** (with anticipated platelets dysfunction and post cardiopulmonary by pass)
- **Otherwise healthy children** with anticipated blood loss of at least one blood volume or more
- **Starting patients platelet count is a reliable predictor of thrombocytopenia with bleeding**
  - Children with starting plt. ~ 100,000 mm^3 are likely to become thrombocytopenic after loosing only one blood volume lost
  - Plan in advance if need for platelets is anticipated confirm with blood bank, to have platelets in hospital available

Platelets Transfusion

- **Acute thrombocytopenia**
  - due to surgical blood loss / CPB below 50,000 /mm^3 results in bleeding - consider platelet transfusion
- **Chronic thrombocytopenia**
  - ITP, chemotherapy, infection, DIC as low as 5,000 to 10,000 /mm^3 is tolerated well if patient present for minor surgery
- **Antibody to platelets** are common after previous platelets transfusion - therapy, to give more platelets

Complications of Massive Transfusion

- Depletion of platelets, coagulation factors
- Hyperkalemia - with blood ages $K^+ \uparrow$
- Hypokalemia - with frozen red blood cells
- Ionized hypocalcemia - citrate from FFP or PRBC (Th $CaCl_2$ 2.5 mg/kg or Ca gluconate 7.5 mg/kg)
- Alkalosis - conversion citrate to bicarbonate
- Infection (Hep B, C, HIV, CMV)
- Hypotermia
- Oxyhemoglobin dissociation curve shifting to the left

Autologous Blood Transfusion

- **Preoperative blood donation**
  - Hct ≥ 33% before phlebotomy
  - < 15% of EBV at time
  - more than 4 years old
- **Acute normovolemic hemodilution**
  - more than 8 moths old
  - lowest Hct 20%-30%
- **Intra-end postoperative blood salvage**

Some values for Hct(bp)

Product	Hct.
Citrated Whole Blood(2 wk old)	35
Citrated Packed RBC's	50
Citrated Spun Packed RBC's	70
Processed Frozen RBC's	50
Processed Frozen RBC's(max)	80
Autologous Salvaged RBC's(Cell Saver)	any of the above*

- *Blood collected intraoperatively may have extremely varied hematocrits and should he measured if the calculations are critical.