Interpretation of laboratory values

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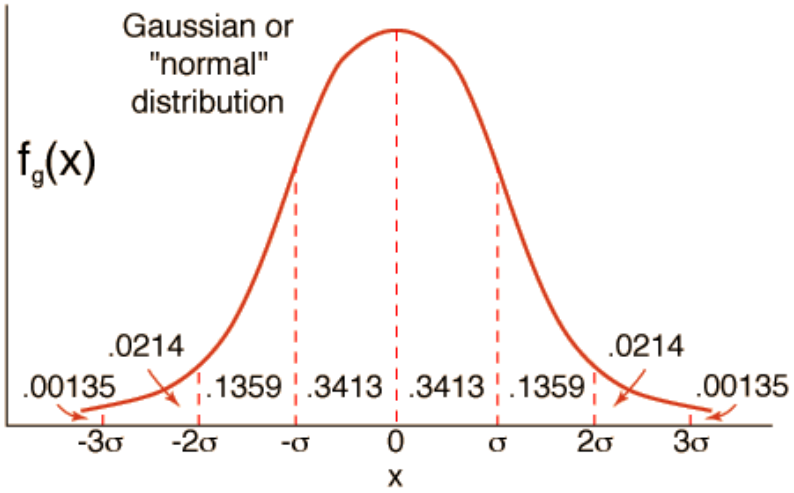
Normal values

- Age specific
- Gender specific
- Daily rhythm
- Laboratory specific!

What is normal?



Eg. Height, weight

Vs.

Risk

Eg. Glucose, blood pressure

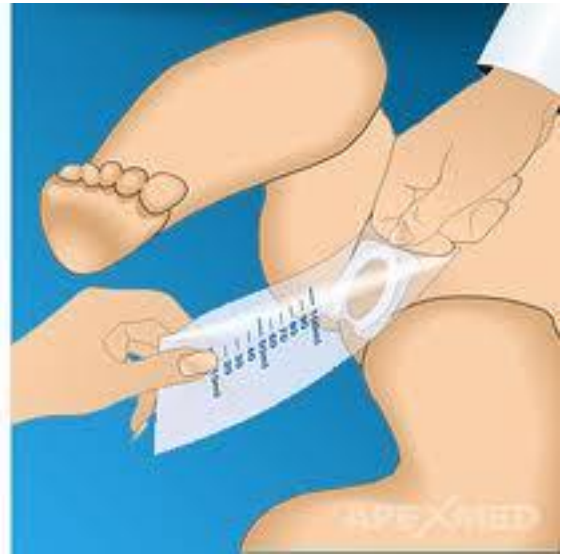
Preanalytical concerns

- Blood volume
  - Newborn: 250-300 ml vs. adult: 4700-6100 ml
  - Vacuum container collapses small veins: hemolysis
  - Capillary puncture: prewarm
  - Microanalytical methods!

PLAN AHEAD!

Preanalytical concerns

- Urine collection



Sodium (Na)

Sodium (P)[1]	
Newborns:	133–146 mmol/L
Children and adults:	135–148 mmol/L

- Neonatal fluid compartments!, increased insensible water loss (surface, respiratory rate), immature renal function
- Pseudohyponatremia: protein, glucose

Potassium (K)

Potassium (S, P)[2]	
Premature infants:	4.5–7.2 mmol/L
Full-term infants:	3.7–5.2 mmol/L
Children:	3.5–5.8 mmol/L
Adults:	3.5–5.5 mmol/L

- Compression – hemolysis – K ↑
- Might come from muscle injury (birth)
- Extremely ↑ WBC: K comes out
- Acidosis
- Frequent, rapid transfusions

Calcium (Ca)

Calcium (S)[2]	
Premature infants (first week):	3.5–4.5 mEq/L (1.7–2.3 mmol/L)
Full-term infants (first week):	4.0–5.0 mEq/L (2.0–2.5 mmol/L)
Thereafter:	4.4–5.3 mEq/L (2.2–2.7 mmol/L)

- Ionized vs. total Ca
- 99% in hydroxyapatite, bone mass grow faster than body weight
- Citrated transfusion: hypocalcemia, but total Ca is normal (Ca-citrate complex)

ABG

Base Excess (B)[1]	
Newborn:	–10 to –2 mmol/L
Infant:	–7 to –1 mmol/L
Child:	–4 to +2 mmol/L
Thereafter:	–3 to +3 mmol/L

Bicarbonate, Actual (P)[2]	
Calculated from pH and $PaCO_2$	
Newborns:	17.2–23.6 mmol/L
2 months–2 years:	19–24 mmol/L
Children:	18–25 mmol/L
Adult males:	20.1–28.9 mmol/L
Adult females:	18.4–28.8 mmol/L

PH (B)[1]	
0–6 months	7.18–7.50
6–12 months	7.27–7.49

Alkaline phosphatase (ALP)

Alkaline Phosphatase (S)[2]

Values in IU/L at 37°C (98.6°F) using p-nitrophenol phosphate buffered with AMP (kinetic).

Age	Males	Females
Newborns (1–3 days)	95–368	95–368
2–24 months	115–460	115–460
2–5 years	115–391	115–391
6–7 years	115–460	115–460
8–9 years	115–345	115–345
10–11 years	115–336	115–437
12–13 years	127–403	92–336
14–15 years	79–446	78–212
16–18 years	58–331	35–124
Adults	41–137	39–118

- Intestinal, bone, liver
- Puberty!

Bilirubin

Bilirubin, Conjugated (S)[1]	
Neonates:	<10 µmol/L
Neonate:	<2 µmol/L
Preterm (1–6 days):	<10 µmol/L

- Hyperbilirubinemia interferes with colorimetric assays

Lipids

Cholesterol, High-Density Lipoprotein (S)[1]

1–9 years:	35–82 mg/dL	(0.91–2.12 mmol/L)
10–13 years:	36–84 mg/dL	(0.93–2.17 mmol/L)
14–19 years:	35–65 mg/dL	(0.91–1.68 mmol/L)

Cholesterol, Low-Density Lipoprotein (S)[1]

5–9 years:	63–140 mg/dL	(1.63–3.63 mmol/L)
10–14 years:	64–136 mg/dL	(1.66–3.52 mmol/L)
15–19 years:	59–137 mg/dL	(1.53–3.55 mmol/L)

Cholesterol, Total (S, P)[1]

1–3 years:	44–181 mg/dL	(1.15–4.70 mmol/L)
4–6 years:	108–187 mg/dL	(2.80–4.80 mmol/L)
7–9 years:	112–247 mg/dL	(2.90–6.40 mmol/L)
10–13 years:	125–244 mg/dL	(3.25–6.30 mmol/L)
14–19 years:	106–224 mg/dL	(2.75–5.80 mmol/L)

Triglycerides (S)[1]

Values in mg/dL (mmol/L)

Age	Males	Females
1–3 years	27–125 (0.31–1.41)	27–125 (0.31–1.41)
4–6 years	32–116 (0.36–1.31)	32–116 (0.36–1.31)
7–9 years	28–129 (0.32–1.46)	28–129 (0.32–1.46)
10–11 years	24–137 (0.27–1.55)	39–140 (0.44–1.58)
12–13 years	24–145 (0.27–1.64)	37–130 (0.42–1.47)
14–15 years	34–165 (0.38–1.86)	38–135 (0.43–1.52)
16–19 years	34–140 (0.38–1.58)	37–140 (0.42–1.58)

- Lipemia: spectrophotometer with flame photometer won’t work

Creatine

Creatine (S, P)[2]

Values in mg/dL (µmol/L)

Age	Males	Females
1–3 days[a]	0.2–1.0 (17.7–88.4)	0.2–1.0 (17.7–88.4)
1 year	0.2–0.6 (17.7–53.0)	0.2–0.5 (17.7–44.2)
2–3 years	0.2–0.7 (17.7–61.9)	0.3–0.6 (26.5–53.0)
4–7 years	0.2–0.8 (17.7–70.7)	0.2–0.7 (17.7–61.9)
8–10 years	0.3–0.9 (26.5–79.6)	0.3–0.8 (26.5–70.7)
11–12 years	0.3–1.0 (26.5–88.4)	0.3–0.9 (26.5–79.6)
13–17 years	0.3–1.2 (26.5–106.1)	0.3–1.1 (26.5–97.2)
18–20 years	0.5–1.3 (44.2–115.0)	0.3–1.1 (26.5–97.2)

[a] Values may be higher in premature newborns.

Creatinine Clearance[2]

Values show great variability and depend on specificity of analytical methods used.

Newborns (1 day):	5–50 mL/min/1.73 m^2 (mean, 18 mL/min/1.73 m^2)
Newborns (6 days):	15–90 mL/min/1.73 m^2 (mean, 36 mL/min/1.73 m^2)
Adult males:	85–125 mL/min/1.73 m^2
Adult females:	75–115 mL/min/1.73 m^2

- Preterm ↑
- ≈muscle mass
- GFR: adjust medication dose!
- Bilirubin, lipemia, hemolysis interferes with assay

Inflammation markers

C-Reactive Protien (S)[1]	
Cord blood:	10–350 µg/L
Adult:	68–8,200 µg/L

Sedimentation Rate (Micro) (B)[2]	
<2 years:	1–5 mm/hr
>2 years:	1–8 mm/hr

- Different kinetics
- Viral/bacterial/fungal

Blood count

Hematocrit (B)[1]

Age	Males (%)	Females (%)
Newborns	43.4–56.1	37.4–55.9
6 months–2 years	30.9–37.0	31.2–37.2
2–6 years	31.7–37.7	32.0–37.1
6–12 years	32.7–39.3	33.0–39.6
12–18 years	34.8–43.9	34.0–40.7
>18 years	33.4–46.2	33.0–41.0

Hemoglobin (B)[1]

Age	Males (g/dL)	Females (g/dL)
Newborns	14.7–18.6	12.7–18.3
6 months–2 years	10.3–12.4	10.4–12.4
2–6 years	10.5–12.7	10.7–12.7
6–12 years	11.0–13.3	10.9–13.3
12–18 years	11.5–14.8	11.2–13.6
>18 years	10.9–15.7	10.7–13.5

White Blood Cell Count (B)[1]

Values $\times 10^3/\mu L$. ($\mu L = mm^3$)

Age	Males	Females
Newborns	6.8–13.3	8.0–14.3
6 months–2 years	6.2–14.5	6.4–15.0
2–6 years	5.3–11.5	5.3–11.5
6–12 years	4.5–10.5	4.7–10.3
12–18 years	4.5–10.0	4.8–10.1
>18 years	4.4–10.2	4.9–10.0

Platelet Count (RBC)[1]

Value $\times 10^3/\mu L$. ($\mu L = mm^3$)

Age	Males	Females
Newborns	164–351	234–346
1–2 months	275–567	295–615
2–6 months	275–566	288–598
6 months–2 years	219–452	229–465
2–6 years	204–405	204–402
6–12 years	194–364	183–369
12–18 years	165–332	185–335
>18 years	143–320	171–326

Lowest Hb: 8-12 weeks (normochromic and microcytic with normal ret.)

Low pO2 in utero: Epo

Premie: earlier and lower Hb decrease (70-90): shorter life of RBCs (65 days) and inadequate Epo synthesis

Fetal hemoglobin

High ret count – high PLT

Ly/Neu 80/20 ➔20/80

A Case of Hyponatremia and Seizures

N. A., A 2-DAY-OLD FEMALE, is currently in the neonatal ICU being treated with antibiotics for suspected sepsis. This morning N. A. began having rhythmic clonic twitching of her lower extremities, fluttering of her eyelids, and repetitive chewing movements, consistent with seizure activity. N. A. was born at 39 weeks gestation to a mother with prolonged rupture of membranes (>72 hours). On the day of her birth, N. A. was admitted to the neonatal ICU with an elevated temperature, tachycardia (HR 153) and low WBC count (3.5 x 10^3 cells/mm^3). Blood and urine cultures were obtained and antibiotics were started to treat her possible sepsis. Culture results are still pending. Medications include: ampicillin 85 mg IV in 25 mL D5W as IV rider q 8 hr (75 mg/kg/day) and gentamicin 8.5 mg IV in 25 mL D5W as IV rider q 12 hr (5 mg/kg/day).

N. A.'s vital signs include: BP 76/46 mm Hg, HR 125 beats/min, RR 35 breaths/min, and temperature 98.8°F. Length is 49 cm (50th percentile for age) and weight is 3.4 kg (50th percentile for age). Laboratory data includes: sodium 120 mEq/L, potassium 3.9 mEq/L, chloride 98 mEq/L, total CO_2 20 mEq/L, BUN 8 mg/dL, SCr 0.8 mg/dL, and glucose 87 mg/dL.

Question: What is the most likely cause of this patient's seizure activity and electrolyte imbalance? What other laboratory tests should be

Discussion: Electrolyte imbalance is a common cause of neonatal seizures. As in adults, hyponatremia may cause seizure activity in neonates and occurs when the ratio of water to sodium is increased. The total body content of sodium in patients with hyponatremia may be low, normal or high, and the volume status may be hypovolemic, euvolemic or hypervolemic. There are many causes of hyponatremia, but the most likely cause in this patient is the extra D5W that the patient received with her antibiotics. Dilutional hyponatremia may occur in neonates and young infants when medications are administered in excess fluids, such as IV riders of 5% dextrose in water. These patients are more prone to water overload due to their lower glomerular filtration rate and their limited ability to excrete water. Medications for these patients should be diluted in smaller amounts of IV fluid, so that excess fluid is not administered. To better define this patient's sodium and volume status, N. A.'s total fluid intake and output, type of IV fluids administered, changes in body weight, and other laboratory data need to be assessed. In addition, other causes of hyponatremia, such as meningitis and SIADH, should be ruled out. It should be noted that a low WBC, as observed in N. A., often occurs in neonates with a serious bacterial infection (see section on White Blood Cell Count). Although the most likely cause of this patient's seizure activity is her low serum sodium, serum calcium, phosphorous, and magnesium should also be assessed, as other electrolyte abnormalities can also cause seizure activity.

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Vancomycin Dose Determination Based on Estimated Creatinine Clearance in a Child

M. R., A 4-YEAR-OLD FEMALE, is currently in the PICU recovering from cardiac surgery (post-operative day 7). M. R.'s blood culture today is positive for methicillin-resistant *Staphylococcus aureus* and vancomycin therapy is to be initiated. Vital signs include: BP 95/62 mm Hg, HR 142 beats/min, RR 27 breaths/min, and temperature 101.2°F. Her height is 101 cm (50th percentile for age); weight is 16 kg (50th percentile for age); body surface area is 0.67 m^2. Laboratory data includes: sodium 140 mEq/L, potassium 3.8 mEq/L, chloride 102 mEq/L, total Co_2 28 mEq/L, BUN 42 mg/dL, SCr 2.4 mg/dL, and glucose 109 mg/dL.

Question: Knowing the following information, what dose of vancomycin would you recommend for this patient?

The normal dose of vancomycin used at this hospital for a child of this age is 40 mg/kg/day divided q 6 hr. The recommended dosing adjustment for patients with renal dysfunction is as follows:[1]

CrCl 70–89 mL/min/1.73m^2: Administer the normal dose q 8 hr

CrCl 46–69 mL/min/1.73m^2: Administer the normal dose q 12 hr

Discussion: Vancomycin is primarily eliminated by glomerular filtration in the kidney; 80% to 90% of a dose is excreted in the urine as unchanged drug. M. R.'s BUN and SCr are elevated indicating that she has renal impairment. Thus, the dose of vancomycin must be adjusted for her renal dysfunction. In order to recommend an appropriate dose, M. R.'s CrCl needs to be calculated. An estimation of CrCl from M. R.'s SCr and height can be obtained by using equation (5) and the k value of 0.55 for children 2–12 years of age (Table 19-3). M. R.'s estimated CrCl is 23 mL/min/1.73 m^2. To determine the appropriate dose of vancomycin, one must first calculate the normal dose (i.e., as if the patient did not have any renal dysfunction), and then adjust the dose according to the given guidelines. Since M. R. weighs 16 kg, the normal dose of vancomycin would be 160 mg q 6 hr (40 mg/kg/day divided q 6 hr). Since M. R.'s CrCl is 23 mL/min/1.73m^2, she should receive 160 mg q 24 hr. Appropriate therapeutic drug monitoring should be performed to adjust this initial dosing regimen.

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This is a 3 week old male infant who presents to the emergency department with a chief complaint of vomiting x 3-4 days. His mother states that the vomiting has gotten progressively worse and now seems to "shoot out of his mouth." The emesis always occurs after feeding, sometimes vomiting the entire volume of his feed. The vomitus is non-bilious and non-bloody. After vomiting, the infant remains hungry and is still eager to feed. He is exclusively bottle fed with formula. There is no history of fever, URI symptoms, or diarrhea. He is less active than normal. He is making fewer wet diapers and less stool than usual. There is no history of trauma or recent travel. There are no ill contacts.

Exam: VS T 37.0, P 170, R 50, BP 80/50, O2 saturation 99% on RA. Length is 54 cm (50th percentile) and weight is 3.6 kg (25th percentile; previously 50th) and head circumference is 37 cm (50th). He is a well-developed, well-nourished male in no distress. His skin is normal. HEENT exam is normal. His neck is supple. Heart auscultation reveals tachycardia and a regular rhythm. Lungs are clear. His abdomen is slightly distended with active bowel sounds. No hepatosplenomegaly is noted. Attempting to palpate an olive mass is inconclusive. He has no inguinal hernias. Genitalia are normal. Extremities are normal. Color, perfusion, and capillary refill are good. Neurologic examination is normal.

CBC is unremarkable. Electrolytes: Na 131, K 3.2, Cl 95, bicarb 30. An IV fluid infusion is started. An abdominal series shows no obstruction, but the stomach is dilated. An ultrasound study confirms the diagnosis of pyloric stenosis. The patient undergoes a pyloromyotomy and recovers without complications.

A previously healthy 4 year old boy is brought to an urgent care center by his mother for difficulty breathing for one day. Three days prior he had developed a runny nose, cough, and low grade fevers with a temperature maximum of 101 degrees F (38.3 degrees C). He continued to take liquids well, but his solid intake has decreased. His temperature this morning was 103 degrees F (39.4 degrees C) and he was breathing fast and working hard to breathe. He does not have any ill contacts. He has never been hospitalized or had any surgeries. He was born at term without any complications. He is not taking medications other than acetaminophen. His immunizations are up to date for his age (except he had not received the pneumococcal conjugate vaccine). His parents and 10 year old sister are healthy and the remainder of his family history is non-contributory. There are no smokers in the household, and he has not traveled recently. He does not have a history of choking or vomiting. He has not had frequent ear or skin infections. He does not have a history of foul-smelling stools.

Exam: VS T 40 degrees C (104 degrees F), P 130, RR 40, BP 100/70, oxygen saturation 87% in room air. His height and weight are in the 50th percentile for his age. He is awake and alert, in moderate distress. His conjunctiva and TMs are normal. His nasal mucosa is erythematous with yellowish discharge. His lips and mucous membranes are dry. His neck is supple, with several small anterior cervical lymph nodes. Lungs: Moderate subcostal, intercostal, and supraclavicular retractions, symmetric expansion, dullness to percussion at the right base, increased vocal fremitus over the right base, decreased air entry over right lower lobe with crackles, no wheezes. Heart: Tachycardia, regular rhythm without murmur. Pulses are 2+, and capillary refill time is 3 seconds. His abdomen, skin, and neurological examinations are unremarkable.

CBC WBC 20,000, 70% segs, 11% bands, 15% lymphs, 3% monos, 1% eos. Hemoglobin 12.4, platelet count 280,000. Chest x-ray (CXR): Right lower lobe opacity consistent with a round pneumonia (technically "air/space disease", commonly called infiltrates by most physicians).

Because of the hypoxia, he is given supplemental oxygen (with subsequent improvement in oxygen saturation), as hospitalization arrangements are made. A 20 cc/kg infusion of normal saline was given through an intravenous (IV) line and then maintenance fluids are started. A blood culture is obtained and he is started on IV cefuroxime. He improves over the next day. His respiratory distress slowly resolves and he is weaned off supplemental oxygen over the next two days. His blood culture shows no growth. He is discharged home on high dose amoxicillin for a total of 10 days of therapy. His discharge diagnosis is probably pneumococcal pneumonia.

This is a 9 year old boy who has enjoyed his usual state of good health until his polyuria started 2 months ago. He began to lose weight and reported worsening nocturia over this same period. His appetite increased although lately he has more episodes of stomachaches. Today, he had a noticeably sweet smell to his breath and he was breathing faster than usual so his mother brought him to his pediatrician.

Exam: VS T 37.0, RR 44, P 92, BP110/60, oxygen saturation 100% on room air. His weight was 25 kg (25%tile). He is alert and cooperative. His skin is warm to his wrists and ankles. His oral mucous membranes are tacky. His capillary refill is 3 seconds over his chest. His skin was otherwise normal. His thyroid gland is approximately 1.5 times the normal size. His heart rate is regular. He is slightly tachypneic with clear breath sounds. His reflexes are normal. His abdomen has normal bowel sounds has no tenderness. His genitalia and pubic hair are in Tanner stage I. The rest of the physical examination is unremarkable.

His pediatrician suspects new onset diabetes mellitus. A urine dipstick in the office shows 4+ glucose and 2+ ketones. No other dipstick abnormalities are noted. He is clinically stable. He is hospitalized for further management and treatment. His initial lab studies show Na 132, K3.3, Cl 99, bicarb 11, glucose 380, BUN 21, creatinine 0.4. He is started on an IV fluid infusion and subcutaneous insulin.